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The American Midland Naturalist

Founded by J. A. Nieuwland, C.S.C.

John D. Mizelle, *Editor*

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A Taxonomic Study on the Grasses of Pennsylvania

Richard W. Pohl

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Introduction

This work consists of an annotated catalogue of the grass flora of Pennsylvania with keys to tribes, genera and species, and discussion of ranges, habitat preferences and seasonal occurrence. The nomenclature and arrangement of genera and species in general follow that of Hitchcock (1935). Synonyms are cited only when the name employed differs from that used in Hitchock's Manual.

Species have been admitted to the systematic list only on the basis of specimens in institutional herbaria which the author has seen. An effort was made to verify older reports of various species from Pennsylvania, but in those cases where confirmatory specimens could not be found, the species have been excluded. These cases are discussed in the list of excluded species. The systematic treatment is based upon the grasses in the herbaria of the University of Pennsylvania, the Academy of Natural Sciences of Philadelphia, the Philadelphia Botanical Club at the Academy of Natural Sciences, the Carnegie Museum at Pittsburgh, and the State Herbarium at Harrisburg. Small numbers of specimens also were loaned for study by the U. S. National Herbarium, the New York Botanical Garden, the Gray Herbarium, and the herbaria of Cornell University, The University of Michigan and the University of Wisconsin. To the curators of all these herbaria, the author wishes to express his deepest appreciation for their cooperation. Because of the very large number of specimens examined in this study, citation of specimens has been omitted except in the few cases of very rare species.

Measurements used in the keys are based primarily on specimens from

Pennsylvania. All measurements stated to tenths of millimeters were made with a Bausch and Lomb low power binocular microscope, equipped with 1.5X objectives and 10X wide field oculars, one of which was furnished with an ocular micrometer, which was standardized against a stage micrometer.

The seasonal occurence of the species of grasses has been indicated in the treatments of the individual species. The limits given represent the period during which well developed and intact inflorescences are present on the plants; they are not actual flowering dates, which would cover a somewhat shorter period.

The following abbreviations and symbols have been used in the text.

*	Refer to Excluded Species p.598-600	C.	Herbarium of the Carnegie Museum at Pittsburgh
cm.	Centimeter	H.	Pennsylvania State Herbarium, Harrisburg
dm.	Decimeter	P.	Herbarium of the University of Pennsylvania at Philadelphia
mm.	Millimeter	S.	Herbarium of Pennsylvania State College, State College, Pa.
m.	Meter	U.S.	United States National Herbarium, U. S. National Museum, Washington, D. C.
f.	Forma		
var.	Variety		
A.	Herbaria of the Academy of Natural Sciences of Philadelphia and the Philadelphia Botanical Club at Philadelphia		

THE QUESTION OF HYBRIDITY

In a group of wind pollinated, widespread and numerous plants such as the grasses, numerous opportunities for cross-pollination must occur. Nevertheless, the number of presumptive hybrids in our grass flora is exceedingly small. The plants mentioned below as possible or probable hybrids are of very rare occurrence. The plants may be sterile and are usually found occurring with one or both of the putative parents. Genetic and cultural studies on these plants should give further indication of their exact nature. Further discussion of the individual cases will be found in the systematic treatment as indicated.

Elymus sp. x *Hystrix patula*	See *Hystrix* p. 550
Sphenopholis pallens	See *Sphenopholis* p. 553
Muhlenbergia curtisetosa	See *Muhlenbergia* p. 563
Panicum bicknellii	See *Panicum* p. 577
P. recognitum	See *Panicum* p. 585
P. commutatum, var. *ashei* x *P. boscii*	See *P. commutatum*, var. *ashei* p. 585

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For his encouragement and advice, and the generous extension of many facilities which aided in the work, the author wishes to thank Dr. John M. Fogg, Jr. Dr. Edgar T. Wherry has furnished information in geographical matters; his assistance is sincerely appreciated. Mrs. Agnes Chase, Custodian of Grasses at the United States National Herbarium, has given helpful advice on special problems and has checked the identity of a number of specimens and has facilitated the loan of specimens for study. I am most grateful to Mrs. Chase for her aid. Mr. Bayard Long, Curator of the excellent local herbarium of the Philadelphia Botanical Club, has been most generous with both his time and his wide and accurate field knowledge of the grasses of the eastern United States.

The continuance of this work has in large measure been aided by a National

Research Council Pre-Doctoral Fellowship held by the author from November, 1945 to June, 1947. Field studies during the summer of 1946 were aided by a Grant-in-Aid by the University of Pennsylvania Chapter of the Society of the Sigma Xi.

The Grass Flora

The current grass flora of Pennsylvania is here recognized as containing 233 species and 40 varieties and named forms. Of this number, 148 species, 4 named hybrids, and 32 varieties and forms, or 67% of the total are native, and 81 species and 8 varieties and forms, or 33% have been introduced. In addition to the foregoing, 38 other species have been collected in the state at one or more times in the past, but because of the lack of collections since 1900, are regarded as no longer a part of the flora.

An attempt has been made in the following lists to group the native grass flora into several categories on the basis of the major types of ranges and habitat preferences which the species exhibit. More detailed statements of ranges and habitats are given in the systematic treatment.

NATIVE GRASS SPECIES

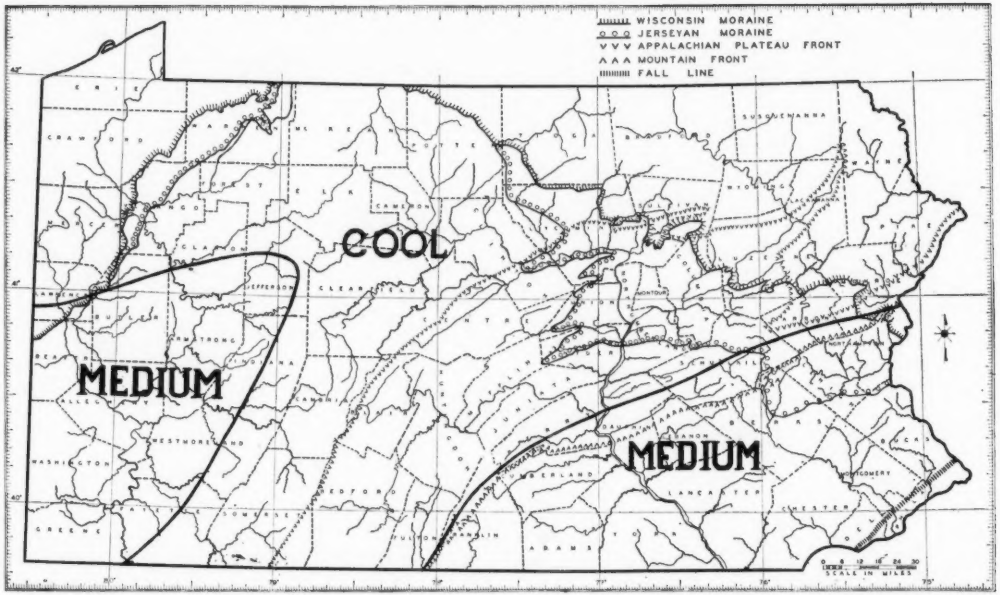
SPECIES OF WIDE RANGE

The following species are widely dispersed in Pennsylvania, although some of them may be restricted to special habitats. Within the state, they are not limited in distribution to any particular climatic or physiographic area.

Bromus purgans
Festuca obtusa
Glyceria melicaria
G. striata
Eragrostis pectinacea
Hystrix patula
Sphenopholis intermedia
S. nitida
Deschampsia flexuosa
Danthonia spicata
D. compressa
Calamagrostis cinnoides
Agrostis perennans
Cinna arundinacea
Alopecurus aequalis
Muhlenbergia sobolifera
M. tenuiflora
M. glomerata
M. frondosa
M. sylvatica
M. mexicana
M. schreberi
Sporobolus vaginaeflorus
Oryzopsis racemosa
Leersia virginica
L. oryzoides
Panicum depauperatum and var. *psilophyllum*
Panicum linearifolium and var. *werneri*
P. dichotomum
P. implicatum
P. columbianum
P. sphaerocarpon
P. scribnerianum
P. commutatum, var. *ashei*
P. clandestinum
P. latifolium
P. dichotomiflorum
P. gattingeri
P. philadelphicum
P. capillare and var. *occidentale*
Cenchrus pauciflorus

The Relationship of Temperature to the Distribution of Species of Grasses in Pennsylvania

Livingston (1916) studied the relationship of plant growth to temperature and devised physiological temperature indices. On the basis of these "physiological summation indices of temperature efficiency for plant growth", Livingston, and later Livingston and Shreve (1921) divided the United States



Map 1.—Climatic Zones in Pennsylvania. (Adapted, from Livingston and Shreve). The boundaries have been modified in detail to fit the distribution patterns of the following species: In the "Cool" zone: *Bromus ciliatus, B. kalmii, Glyceria acutiflora, G. borealis, G. pallida* var. *fernaldii, G. grandis, Poa saltuensis, P. palustris, P. languida, P. alsodes, Schizachne purpurascens, Elymus wiegandii, Agropyron trachycaulum* and vars., *Calamagrostis porteri, Cinna latifolia, Brachyelytrum erectum, var. septentrionale, Milium effusum.* In the "Medium" zone: *Poa cuspidata, P. autumnalis, P. sylvestris, Trisetum pennsylvanicum, Brachyelytrum erectum* (typical), *Agrostis hyemalis, Paspalum ciliatifolium,* var. *muhlenbergii, P. laeve* and var. *circulare.*

into climatic zones, two of which occur in Pennsylvania, as shown on Map 1. The boundaries of these two zones correspond very well to the geographic limits of the two groups of species here listed as having northern or southern ranges. Not only grass species, but numerous others have ranges which are similarly bounded in our area. The Coastal Plain species which enter Pennsylvania are largely restricted to the area of "medium" climate in the southeastern portion of the state.

SPECIES OF NORTHERN RANGE

This group of species includes those, the general body of whose ranges lie to the north of Pennsylvania, but which enter northern Pennsylvania and frequently extend southward through the state in the mountains. Their ranges in Pennsylvania correspond rather closely to the "cool" climatic zone of Livingston and Shreve. Where the ranges of these plants transgress the boundaries of this zone, they are usually found in cool swamps, north-facing slopes and similar habitats.

Bromus ciliatus
B. kalmii
Glyceria borealis
G. acutiflora (also on Coastal Plain in s.e. Penna.)
G. grandis
G. pallida, var. *fernaldii*
Poa alsodes
P. saltuensis
P. palustris
Schizachne purpurascens
Elymus wiegandii
Agropyron trachycaulum and vars.
Trisetum spicatum
Calamagrostis porteri
Agrostis scabra
Cinna latifolia
Muhlenbergia uniflora
Brachyelytrum erectum, var. *septentrionale*
Milium effusum
Oryzopsis pungens
O. asperifolia
Panicum boreale
P. xanthophysum

SPECIES OF SOUTHERN RANGE

In the following group are included those species whose general ranges lie mostly to the south of Pennsylvania, with extensions northward on or near the Coastal Plain. Within the state, their ranges are mostly limited to the "medium" climatic zone of Livingston and Shreve, or at low altitudes within the boundaries of the "cool" zone.

Festuca paradoxa
Poa cuspidata
P. sylvestris
P. autumnalis
Eragrostis capillaris
Uniola latifolia
U. laxa
Trisetum pennsylvanicum
Agrostis hyemalis
A. elliottiana
Muhlenbergia capillaris
Sporobolus clandestinus
Brachyelytrum erectum (typical)
Gymnopogon ambiguus
Digitaria filiformis
Paspalum laeve and var. *circulare*
P. ciliatifolium var. *muhlenbergii*
Panicum yadkinense
P. polyanthes
P. commutatum
P. boscii and var. *molle*
P. anceps
P. stipitatum
Setaria geniculata
Andropogon virginicus
Tripsacum dactyloides

P. laeve and var. *circulare*.

ATLANTIC COASTAL PLAIN SPECIES

A number of species of grasses, listed below, which are common on the sandy lands, bogs or salt marshes of the Atlantic Coastal Plain also extend into Pennsylvania, where they are mostly localized on the Coastal Plain and lower Piedmont, in the southeastern portion of the state. Some of these species occur on the serpentine barrens of the lower Piedmont, in Delaware, Chester and Lancaster Counties. *Glyceria obtusa* occurs on the Coastal Plain and in the post-glacial bogs of the Pocono Plateau, in association with other characteristic plants of the Atlantic Coastal Plain. *Andropogon virginicus*, var. *abbreviatus*, also common on the Coastal Plain, has recently been found in the mountain bogs of Fayette and Somerset Counties.

Glyceria obtusa
Uniola laxa
Stipa avenacea
Aristida purpurascens
Paspalum setaceum
P. distichum
P. psammophilum
P. floridanum, var. *glabratum*
Leptoloma cognatum
Panicum annulum
P. spretum
P. lindheimeri
P. scoparium
P. lucidum
P. longifolium
Echinochloa walteri
Erianthus saccharoides
Andropogon elliottii
A. virginicus, var. *abbreviatus*

Ammophila breviligulata, a maritime species, and *Andropogon scoparius*, var. *littoralis*, the maritime variety of the common little bluestem, occur on the Atlantic Coast and on the sand beaches of Lake Erie, in Erie county. They are not known from other points in Pennsylvania. This type of disjunct range is probably the result of the migration of these species inland to the Great Lakes region during the late Pleistocene or post-Pleistocene time, along the outlets of the Glacial Great Lakes, as postulated by Peattie (1922). At their inland station in Erie County, these species are accompanied by such other characteristic Coastal Plain or littoral species as *Lathyrus japonicus* Willd., var. *glaber* (Ser.) Fernald, *Euphorbia polygonifolia* L., and *Cakile edentula* (Bigel.) Hook. (in the latter case, the inland var. *lacustris* Fernald). *Panicum commonsianum*, var. *euchlamydeum*, also present on Presque Isle, is a post-Pleistocene derivative of the Coastal Plain. *P. commonsianum*.

Four other species of wider general distribution show in Pennsylvania disjunct ranges similar to those exhibited by the previous two species. *Phragmites communis* and *Zizania aquatica* (Coastal Plain) and its var. *angustifolia* (Lake Erie) are aquatic species and the disjunction in this case is probably due to lack of suitable habitats at intervening points. *Triplasis purpurea* and *Sporobolus cryptandrus*, with similar distributions, are sand-plain inhabitants, and like the previous two species, are probably absent from the remainder of the state because of their habitat requirements.

SPECIES OF RIVER VALLEYS

A fairly large number of our grasses have a marked preference for the habitats afforded by the valleys of the major rivers and their larger tributaries. Most of these species are more common on the alluvium, but some may also occupy the rocky slopes of the valley walls.

Bromus latiglumis
Eragrostis hypnoides
E. frankii
Uniola latifolia
Elymus canadensis
E. wiegandii
E. riparius
E. villosus
E. virginicus and vars.
Hystrix patula, var. *bigeloviana*
Deschampsia cespitosa (Also on serpentine)
Sporobolus asper
Spartina pectinata
Panicum microcarpon
P. agrostoides
P. stipitatum
P. virgatum
P. verrucosum
Andropogon furcatus

AQUATIC OR WET GROUND SPECIES

The grasses of this group range from definite hydrophytes such as *Zizania aquatica* to species like *Glyceria striata*, almost equally at home in rills, wet meadows and moist forests. Because the topography of Pennsylvania is in general well drained, without extensive areas of marshy ground or lakes, these species do not bulk large in our grass flora.

Glyceria acutiflora
G. borealis
G. septentrionalis
G. obtusa
G. melicaria
G. canadensis and var. *laxa*
G. striata
G. grandis
G. pallida and var. *fernaldii*
Poa paludigena
P. palustris
P. trivialis (introduced)
Phragmites communis
Calamagrostis canadensis and var. *macouniana*
Agrostis palustris (introduced)
Phalaris arundinacea
Leersia oryzoides
Zizania aquatica and var. *angustifolia*
Echinochloa pungens
E. walteri
Setaria geniculata

SERPENTINE BARREN GRASSES

These species are found on the serpentine barrens of Delaware, Chester and Lancaster Counties. None are serpentine barrens endemics, but *Panicum annulum* and *Sporobolus heterolepis* have not been found in Pennsylvania away from serpentine, and *Sphenopholis obtusata*, var. *pubescens* is exceedingly rare elsewhere in the state.

Sphenopholis obtusata, var. *pubescens*
Deschampsia cespitosa
Aristida longispica
A. purpurascens
Sporobolus heterolepis
Bouteloua curtipendula
Panicum annulum
P. yadkinense
P. scribnerianum
P. villosissimum
Setaria geniculata

GRASSES COMMON ON LIMESTONE SOILS

Only two species have been detected in our area which appear to have a marked preference for limestone. They are *Bouteloua curtipendula* (also on serpentine) and *Panicum flexile*.

INTRODUCED SPECIES

Included in this list are those species which have entered Pennsylvania through the activities of man and which stray from cultivation or have become

(or may become) a more or less established element of our flora. Old ballast waifs and other rare introductions which presumably have not persisted are treated in the list of excluded species. Most of these grasses are introductions from the Old World, either by accident or through cultivation. The sources of the few introductions from other parts of North America are indicated. Widespread or aggressively weedy species are indicated by a double asterisk.

Pseudosasa japonica
*Bromus inermis***
B. mollis
*B. secalinus***
*B. commutatus***
B. japonicus, var. *porrectus***
*B. sterilis***
*B. tectorum***
*Festuca elatior***
F. ovina
F. capillata
*Poa annua***
*P. compressa***
*P. pratensis***
*P. trivialis***
P. nemoralis
*Eragrostis cilianensis***
*E. poaeoides***
E. pilosa
E. multicaulis
Molinia caerulea
Distichlis spicata
*Dactylis glomerata***
Cynosurus cristatus
*Agropyron repens***
A. pungens
Triticum aestivum
Aegilops cylindrica
A. triuncialis
Secale cereale
Hordeum jubatum (Western U. S.)
H. pusillum (Western U. S.?)
H. vulgare
*Lolium perenne*** and var. *italicum***
Avena sativa
A. fatua
*Arrhenatherum elatius*** and var. *biaristatum*
*Holcus lanatus***
Calamagrostis epigeios
*Agrostis alba***
*A. palustris***
*A. tenuis***
Alopecurus pratensis
*Phleum pratense***
Heleochloa schoenoides
Stipa spartea (Central U. S.)
*Eleusine indica***
Cynodon dactylon
Beckmannia syzigachne (Western and North Central U. S.)
Chloris virgata (Western U. S.)
*Anthoxanthum odoratum***
Phalaris canariensis
*Digitaria sanguinalis***
*D. ischaemum***
Paspalum pubiflorum, var. *glabrum* (Southeastern U. S.)
Panicum leibergii (Central U. S.)
P. miliaceum
*Echinochloa crusgalli*** (introduced?)
*Setaria lutescens***
*S. italica***
*S. viridis***
S. faberii
*S. verticillata***
Pennisetum alopecuroides
Miscanthus sinensis
Eulalia viminea, var. *variabilis*
Sorghum halepense
S. sudanense
S. vulgare
Coix lacryma-jobi
Zea mays

BALLAST PLANTS AND OTHER WAIFS

Between the years 1864-1900 an enthusiastic group of amateur botanists of the Philadelphia area, including Isaac Martindale, Isaac Burk, A. H. Smith, C. E. Smith, Elias Diffenbach, J. B. Brinton and others, collected numerous foreign plants which grew on the earthy ballast brought by ships to the Port of Philadelphia. In more recent years, Mr. Bayard Long has found numbers of these waifs. Most of these plants persisted only a year or two and then disappeared, or in some instances were probably introduced several times over a period of years. Several species also appeared around the Fair Grounds in Philadelphia after the Centennial Exposition of 1876 and later disappeared.

Others were merely rare strays from cultivation which probably have not persisted. All of these species of which there is any reliable record have been included in the keys, but are not included in the body of the text unless there is evidence of their persistence. For convenience they have been listed, with remarks on their occurrence, in the list of excluded species following the systematic treatment. Later introductions, which may still persist, are not included in this list.

Systematic Catalogue of the Grasses of Pennsylvania

KEY TO TRIBES

GRAMINEAE JUSSIEU

1. Spikelets with 1-many florets, mostly laterally compressed or terete; reduced or sterile florets, if present, usually above the fertile florets; disarticulation usually above the glumes: Subfamily Festucoideae.

2. Culms woody, perennial; plants 1-several meters tall, rarely flowering with us ..... I. Bambuseae; See 1. *Pseudosasa*

2. Culms herbaceous, annual.

3. Spikelets in short spikes, each spike enclosed in a spiny bur formed by the glumes of the lower spikelets; spines hooked ..... *Zoysieae: Tragus**

3. Spikelets not enclosed in burs.

4. Inflorescence a panicle (sometimes contracted or spikelike, but the spikelets never sessile and 2-ranked).

5. Glumes lacking or reduced to minute swellings or a ring below the lemma and palea.

6. Spikelets unisexual, the pistillate above and the staminate below in the same inflorescence; tall reed-like aquatic grasses with large terminal panicles ..... IX. Zizaneae; See 60. *Zizania*

6. Spikelets perfect, very flat; our species small to moderate-sized grasses of wet ground or woods ..... VIII. Oryzeae; See 59. *Leersia*

5. Glumes present, sometimes one or both much reduced.

7. Spikelets with one perfect floret, no sterile or rudimentary ones ..... V. Agrostideae

7. Spikelets with 2-many florets, the lower ones sometimes staminate or rudimentary.

8. Glumes shorter than the lowermost floret ..... II. Festuceae

8. Second glume at least as long as the lowermost floret (shorter in *Sphenopholis* with obovate second glume), usually as long as the spikelet.

9. Spikelets with 2-many florets, sterile florets, if present, above the fertile ones and similar to them (lower floret staminate in *Arrhenatherum*) ..... IV. Aveneae

9. Spikelets containing one awnless perfect terminal floret, with one or two dissimilar sterile or staminate florets below it, these often hairy or reduced to minute scales ..... VII. Phalarideae

4. Inflorences of one or more spikes.

10. Spike solitary, terminal, bearing 1-3 spikelets at each node, these two-ranked on opposite sides of the usually zig-zag, continuous or articulate rachis .....III. Hordeae

10. Spikes several, digitate or racemose, bearing spikelets in 2 rows along their lower side .....VI. Chlorideae

1. Spikelets dorsally compressed, with one perfect terminal floret and a sterile (rarely staminate) floret below this; first glume often reduced, sometimes absent; disarticulation below the glumes: Subfamily Panicoideae.

11. Spikelets all alike, in panicles or spikelike racemes; glumes and sterile lemma membranaceous; fertile lemma and palea firm or coriaceous .....X. Paniceae

11. Spikelets paired, usually dimorphic, one pair at each joint of a raceme; glumes coriaceous; sterile lemma, fertile lemma and palea thin, membranaceous.

12. At least one spikelet of each pair perfect and fertile, usually sessile; the other pedicellate, rarely fertile, usually staminate, neuter, or represented only by the pedicel, rarely this also lacking .....XI. Andropogoneae

12. Spikelets all unisexual, the staminate and pistillate ones grouped separately in the same or different inflorescences .....XII. Tripsaceae

KEYS TO GENERA

Tribe I. BAMBUSEAE

This tribe is represented in our flora by a single introduced genus, 1. *Pseudosasa.*

Tribe II. FESTUCEAE

1. Tall grasses; culms 1-several m. tall; panicles large, plumy; rachilla joints elongated, clothed with long hairs .....14. *Phragmites*

1. Plants of small to moderate stature, seldom over 1.5 m. tall; rachilla not clothed with long hairs, occasionally scabrous or puberulent.

2. Plants dioecious, rhizomatous; foliage harsh; panicle small, dense; plants of saline soil, occasional on ballast or waste ground with us .....10. *Distichlis*

2. Plants with perfect flowers.

3. Lemmas 1-3-nerved, the nerves mostly prominent, often hairy.

4. Spikelets paired, one sessile and fertile, the other short-pedicellate, sterile; fertile lemmas 1-nerved; panicle spikelike .....13. *Cynosurus*

4. Spikelets all alike, fertile; lemmas 3-nerved; panicle not spikelike.

5. Spikelets disarticulating above the glumes, or the florets falling and the rachillas persistent.

6. Lemma 2-lobed, the mid-nerve excurrent as a short point; nerves prominently pubescent.

7. Plants perennial, with large exserted open panicles; cleistogamous inflorescences lacking; palea not long-ciliate on the upper half .....17. *Triodia*

7. Plants annual; terminal panicles small, often partly included;

sheaths swollen, containing cleistogamous inflorescences; palea long-ciliate on the upper half ..... 18. *Triplasis*

6. Lemma not lobed, awnless, the nerves glabrous.

8. Spikelets flattened; paleas not longer than the lemmas; rachilla in our species not disarticulating, the paleas often persistent; lemmas deciduous ..... 8. *Eragrostis*

8. Spikelets not flattened; palea of the upper floret longer than the lemma; rachilla disarticulating above the glumes ..... 9. *Molinia*

5. Spikelets disarticulating below the glumes, flattened, 2-flowered, the upper floret awned ..... 28. *Trisetum*

3. Lemmas 5-many-nerved, nerves sometimes inconspicuous (cf. *Sphenopholis* in Aveneae, with obovate second glume, nerveless lemmas, disarticulation below glumes).

9. Nerves of the awnless lemmas parallel, not converging toward the summit.

10. Nerves prominent; widespread plants of moist places and woods ..... 5. *Glyceria*

10. Nerves obscure; low plants of saline soils, ours all ballast waifs ..... 4. *Puccinellia*

9. Nerves of the awned or awnless lemmas converging toward the summit.

11. Lowermost floret of the spikelet sterile; spikelets stiff, very strongly flattened ..... 11. *Uniola*

11. Florets all fertile except some reduced upper ones ..... 12. .....

12. Spikelets strongly flattened, glomerate in dense, one-sided clusters near the tips of the few, rigid panicle branches ..... 12. *Dactylis*

12. Spikelets not strongly flattened, in open or somewhat contracted panicles, not crowded in dense, one-sided clusters.

13. Lemmas as broad as long, closely imbricated, spreading perpendicular to the rachilla, margins not inrolled ..... 7. *Briza*

13. Lemmas longer than broad, not perpendicular to the rachilla, their margins often inrolled.

14. Callus of lemmas pilose or cobwebby.

15. Callus cobwebby; lemmas awnless, the apex entire ..... 6. *Poa*

15. Callus pilose; lemmas awned from a bifid apex ..... 16. *Schizachne*

14. Callus of lemmas not pilose or cobwebby.

16. Upper lemmas of the spikelet closely imbricated, forming a club-shaped sterile rudiment; glumes papery ..... 15. *Melica*

16. Upper lemmas gradually reduced, not imbricated into a sterile rudiment.

17. Lemmas awned.

18. Awns from between the teeth of the bifid apex of the lemma ..... 2. *Bromus*

18. Awns from the tip of the undivided lemma ..... 3. *Festuca*

17. Lemmas awnless or nearly so.

19. Lemmas inflated, papery, very broad, glabrous ..... 2. *Bromus*

19. Lemmas not inflated, narrow.

20. Lemmas keeled, pubescent on the nerves and keel, membranaceous ..... 6. *Poa*

20. Lemmas rounded on the back, glabrous, chartaceous ..... 3. *Festuca*

Tribe III. HORDEAE

1. Spikelets solitary at all nodes of the spike.

2. Spikelets 2-several-flowered, not sunken into the thin internodes of the continuous rachis.

3. Spikelets placed flatwise to the rachis; both glumes developed.

4. Glumes bristle-like; spikelets 2-flowered, the rachilla prolonged beyond the upper floret; lemmas lanceolate, awned, hispid-ciliate on the keel ..... 22. *Secale*

4. Glumes lanceolate to oblong or ovate; spikelets 2-several-flowered.

5. Glumes truncate, 2-keeled, awned; glumes and lemmas bearing fascicles of minute bristles along the keel ..... *Haynaldia**

5. Glumes lanceolate to ovate, rounded or with a single keel, awned or awnless; glumes and lemmas without fascicles of bristles.

6. Glumes lanceolate, acute, more than twice as long as broad; grain permanently enclosed by the lemma and palea; plants perennial ..... 19. *Agropyron*

6. Glumes broadly ovate, less than twice as long as broad; grain free, readily dropping from the floret at maturity; cultivated annuals ..... 20. *Triticum*

3. Spikelets placed edgewise to the rachis, the first glume lacking except in the terminal spikelet ..... 26. *Lolium*

2. Spikelets 1-several-flowered, sunken into the thickened rachis, which disarticulates at full maturity.

7. Spikelets awnless, single-flowered ..... *Parapholis**

7. Spikelets awned, several-flowered ..... 21. *Aegilops*

1. Spikelets 2-several at a node (occasionally solitary in *Hystrix*).

8. Glumes bristle-like, reduced, usually much shorter than the lower floret or wanting; spikelets horizontally spreading at maturity; florets readily deciduous; rachis continuous ..... 24. *Hystrix*

8. Glumes at least as long as the lower floret; spikelets ascending.

9. Spikelets 3 at a node, the lateral two usually much reduced and pedicellate; rachis continuous or disarticulating ..... 25. *Hordeum*

9. Spikelets 2 at a node, similar; rachis continuous ..... 23. *Elymus*

Tribe IV. AVENEAE

1. Spikelets disarticulating above the glumes.
   2. Spikelets 9 mm. long or shorter.
      3. Lemmas acute or short-awned from the tip or between the teeth of a bifid apex ..... *Koeleria**
      3. Lemmas awned from the back.
         4. Awn jointed at the middle, the lower segment brown, with a minute crown at the apex, the upper segment white, club-shaped ..... *Corynephorus**
         4. Awn not jointed, straight or geniculate.
            5. Spikelets 7-9 mm. long; lower floret staminate, with a geniculate exserted awn; upper floret perfect, usually with a shorter, straight awn ..... 31. *Arrhenatherum*
            5. Spikelets 2-6 mm. long, the florets perfect, alike.
               6. Awn inserted near the base of the lemma.
                  7. Rachilla prolonged beyond the base of the upper floret as a minute hairy bristle ..... 29. *Deschampsia*
                  7. Rachilla not prolonged beyond the base of the upper floret ..... *Aira**
               6. Awn inserted above the middle of the lemma ..... 28. *Trisetum*
   2. Spikelets 1-several cm. long.
      8. Lemmas awned from the back; spikelets 2-several-flowered ..... 30. *Avena*
      8. Lemmas awned between the teeth of a bifid apex; spikelets several-flowered ..... 33. *Danthonia*

1. Spikelets disarticulating below the glumes.
   9. Lemmas not awned; glumes unlike in shape, the second obovate and much wider than the first ..... 27. *Sphenopholis*
   9. At least the upper lemma awned.
      10. Disarticulation immediately below the glumes ..... 32. *Holcus*
      10. Disarticulation in the pedicel, the spikelets falling with the stub of the pedicel attached ..... 28. *Trisetum*

Tribe V. AGROSTIDEAE

1. Spikelets disarticulating below the glumes, falling entire.
   2. Glumes bearing awns at least as long as the body ..... *Polypogon**
   2. Glumes not awned.
      3. Panicle spikelike; glumes equal, ciliate, united by their bases ..... 38. *Alopecurus*
      3. Panicle open, drooping; glumes somewhat unequal, not united, short-hispid on the keel ..... 37. *Cinna*

1. Spikelets disarticulating above the glumes, the floret falling.
   4. Fruit dorsally compressed, shining, indurate, awnless ..... 44. *Milium*
   4. Fruit laterally compressed or terete, awned or awnless ..... 5.

5. Glumes minute, the second less than ¼ the length of the floret.

6. Rachilla prolonged behind the palea as a naked bristle; erect, broad-leaved woodland grasses ..... 43. *Brachyelytrum*

6. Rachilla not prolonged; weak, sprawling weedy grasses of disturbed soils ..... 40. *Muhlenbergia*

5. Glumes at least half the length of the floret (awn excluded).

7. Fruit indurate, cylindrical, obscurely-nerved, mostly awned; callus well-developed, bearded, mostly sharp-pointed.

8. Lemma 3-awned, the lateral awns often much reduced ..... 47. *Aristida*

8. Lemma with a single awn or rarely awnless.

9. Awn well-developed, twisted below, not deciduous ..... 46. *Stipa*

9. Awn not twisted, deciduous or lacking ..... 45. *Oryzopsis*

7. Fruit not indurate, without a well-developed callus, awned or awnless, more or less compressed, the nerves evident or obscure.

10. Callus of floret bearded with hairs at least ½ as long as the floret; rachilla usually prolonged as a hairy bristle behind the palea of the awned floret ..... 34. *Calamagrostis*

10. Callus of florets glabrous or short-bearded; rachilla rarely prolonged; florets awnless or awned.

11. Glumes shorter than or equalling the floret.

12. Glumes strongly keeled, acute or truncate.

13. Spikelets 10-20 mm. long; glumes acute, awnless; rachilla prolonged behind the floret; coarse, harsh rhizomatous grasses of sand beaches ..... 35. *Ammophila*

13. Spikelets 5 mm. or less long; glumes usually truncate and with the midnerve prolonged as an awn; rachilla not prolonged; tufted grasses of widespread distribution ..... 39. *Phleum*

12. Glumes acute or acuminate, not strongly keeled.

14. Panicle contracted, spikelike; rhizomes closely covered with imbricated scales ..... 40. *Muhlenbergia*

14. Panicle open or somewhat contracted, not spikelike; rhizomes if present not densely scaly ..... 36. *Agrostis*

11. Glumes shorter than or equalling the floret.

15. Fruit at maturity dropping free from the lemma and palea; pericarp very thin, removable when wet ..... 41. *Sporobolus*

15. Fruit remaining enclosed by the lemma and palea; pericarp attached to the seed.

16. Lemma 3-nerved, mostly awned; perennials, mostly with scaly rhizomes; panicles open or spikelike, not short and included ..... 40. *Muhlenbergia*

16. Lemma 1-nerved, awnless; low annual grasses; panicles short, dense, spikelike, mostly partly included ..... 42. *Heleochloa*

Tribe VI. CHLORIDEAE

1. Spikelets with several perfect florets.

2. Rachis of the spikes extending beyond the spikelets as a naked point; second glume deciduous, awned ..... 49. *Dactyloctenium*

2. Rachis of spikes not prolonged beyond the spikelets; both glumes persistent on the spike, awnless ..... 48. *Eleusine*

1. Spikelets with one perfect floret, sometimes with one or more rudimentary florets above it.

3. Spikelets disarticulating below the glumes, or the spikes falling entire from the rachis.

4. Spikes short, pendant, racemosely arranged along the rachis, falling entire; spikelets with one perfect floret, an awned rudiment above it ..... 55. *Bouteloua*

4. Spikes erect or ascending, not deciduous; spikelets without rudimentary florets.

5. Spikelets nearly circular in outline, apiculate; glumes broadly keeled, rugose, glabrous ..... 51. *Beckmannia*

5. Spikelets ovate in outline, acuminate; glumes narrow, hispid, not rugose ..... 52. *Spartina*

3. Spikelets disarticulating above the glumes; spikes never falling entire.

6. Spikes slender, in open panicles; spikelets distant; lemmas awned ..... 53. *Gymnopogon*

6. Spikes digitate; spikelets not distant.

7. Spikelets with a well developed rudimentary floret above the fertile one; awns present, sometimes minute; plants lacking rhizomes or stolons ..... 54. *Chloris*

7. Spikelets with the rachilla prolonged beyond the fertile floret; rudimentary floret rarely developed; awns lacking; plants with strong creeping rhizomes or stolons ..... 50. *Cynodon*

Tribe VII. PHALARIDEAE

1. The two lower florets as long as or longer than the terminal fertile floret.

2. Lower florets awnless, staminate ..... 56. *Hierochloë*

2. Lower florets awned, sterile ..... 57. *Anthoxanthum*

1. Lower florets one or two, inconspicuous, usually less than half as long as the fertile floret and closely appressed to it; glumes usually winged ..... 58. *Phalaris*

Tribe VIII. ORYZEAE

One genus only in our flora ..... 59. *Leersia*

Tribe IX. ZIZANEAE

One genus only in our flora ..... 60. *Zizania*

Tribe X. PANICEAE

1. Spikelets surrounded by an involucre of bristles or a spiny bur.

2. Spikelets enclosed by spiny burs ..... 3.

3. Spines hooked at the tip ..... *Tragus**

3. Spines straight, without hooked tips ..... 68. *Cenchrus*

2. Spikelets in dense spikelike panicles, each spikelet subtended by one or more bristles.

4. Spikelet or fruit falling, the bristles persistent on the axis of the panicle..... 66. *Setaria*

4. Spikelet and the ring of subtending bristles falling as a unit ..... 67. *Pennisetum*

1. Spikelets not surrounded by an involucre of bristles or a spiny bur.

5. Spikelets arranged in one to several slender, spikelike racemes, usually on the under-sides of more or less flattened axes; first glume minute or lacking.

6. Spikelets elliptic or narrowly ovate, acute; margins of fertile lemma thin, not inrolled; fruit leathery and flexible ..... 61. *Digitaria*

6. Spikelets broadly elliptic or sub-circular, usually obtuse; margins of fertile lemma inrolled; fruit rigid ..... 63. *Paspalum*

5. Spikelets arranged in panicles, rarely somewhat secund along the branches.

7. Spikelets not awned; fertile lemma obtuse to acute, not apiculate.

8. Spikelets disarticulating below the very unequal glumes.

9. Margins of the fertile lemma inrolled; first glume developed .... 64. *Panicum*

9. Margins of fertile lemma thin, not inrolled; first glume minute or lacking ..... 62. *Leptoloma*

8. Spikelets disarticulating above the equal persistent glumes ..... 44. *Milium*

7. Spikelets awned or strongly awn-tipped; fertile lemma apiculate ..... 65. *Echinochloa*

Tribe XI. ANDROPOGONEAE

1. Inflorescence consisting of one or more racemes of many pairs of spikelets, the racemes solitary, digitate, panicled, or aggregated into a corymbose mass.

2. Spikelets unequally pedicellate, all perfect; inflorescence a fan-shaped panicle of numerous long, feathery racemes ..... 69. *Miscanthus*

2. One spikelet of each pair sessile and fertile, the other pedicellate.

3. Pedicellate spikelet fertile, similar to the sessile one.

4. Racemes 1-6, digitate or on a short rachis; spikelets naked or nearly so at the base; low straggling annuals, rooting at the nodes ..... 71. *Eulalia*

4. Racemes numerous, forming an ample panicle; spikelets plumose from the base; tall, stout perennials ..... 70. *Erianthus*

3. Pedicellate spikelets reduced, staminate, neuter or sometimes lacking.

5. Pedicellate spikelet present in all pairs; rachis joints flattened; erect perennial grasses ..... 72. *Andropogon*

5. Pedicellate spikelet and its pedicel present only in the basal pairs of the raceme, or lacking; rachis filiform; low creeping annuals, rooting at the nodes ..... *Arthraxon**

1. Inflorescence an open or contracted terminal panicle of racemes, each of which is reduced to one or a few pairs of spikelets.

6. Pedicellate spikelet present, staminate ..... 73. *Sorghum*

6. Pedicellate spikelet absent, the hairy pedicel only present ..... 74. *Sorghastrum*

Tribe XII. TRIPSACEAE

1. Staminate and pistillate spikelets in the same inflorescence, the staminate spikelets above, the pistillate below.

2. Pistillate portion of the inflorescence 1-2-flowered, enclosed in a bony, bead-like structure; staminate portion of the inflorescence exserted ..... 75. *Coix*

2. Pistillate portion of the inflorescence several to many-flowered, cylindrical, bony, the spikelets sunken into cavities, at maturity this structure disarticulating into one-seeded segments ..... 76. *Tripsacum*

1. Staminate and pistillate inflorescences separate, the former a terminal tassel and the latter aggregated into a thick, cylindrical, leafy-bracted structure, the cob ..... 77. *Zea*

1. PSEUDOSASA Makino

P. JAPONICA (Sieb. & Zucc.) Makino.

Arundinaria japonica S. & Z.

A colony of a small bamboo, identified as this species by Agnes Chase, has existed along the Pennsylvania Railroad embankment at the west end of the South Street Bridge in Philadelphia for at least fourteen years prior to 1946. It is not known how this colony originated, but it is apparently spreading. Smaller colonies have appeared on the sandy flat along the Schuylkill River below the first one noted. The plant has not been known to flower here. An introduction from Japan, this species has been commonly grown in southeastern Pennsylvania.

2. BROMUS L.

WIEGAND, K. M. 1922—Notes on some East-American species of *Bromus*. Rhodora **24**:89-92.

1. Lemmas broad, rounded or tapered to the apex but without acuminate lateral teeth; callus not sharp and prolonged.

2. First glume mostly 1-nerved; glumes lanceolate to narrowly ovate; native perennial species of woodlands and stream banks (except the introduced rhizomatous *B. inermis*).

3. Plants rhizomatous; panicle erect, the branches and spikelets strongly ascending; spikelets linear-lanceolate, glabrous; lemmas awnless or with short awn-tips; introduced perennial, naturalized along roads and on waste ground ..... 1. *B. inermis*

3. Plants not rhizomatous; panicles nodding or with drooping branches; spikelets drooping; lemmas awned; native perennial species of woodlands, thickets and stream banks.

4. Lemmas pubescent along the margins only, glabrous or slightly scaberulous across the back, rarely entirely glabrous; culms with 3-7 nodes (Rare individuals with nearly glabrous lemmas, auriculate sheaths and 10-20 culm nodes belong with *B. latiglumis*).

5. Lemmas pubescent along the margins ..... 2. *B. ciliatus*

5. Lemmas glabrous.

6. Anthers 1.5-2.5 mm. long ..... *B. ciliatus* f. *laeviglumis*

6. Anthers 2.8-4.6 mm. long ..... 3A. *B. purgans*, f. *glabriflorus*

4. Lemmas sparsely to densely pubescent over the back.

7. Culms with 10-20 nodes; sheaths mostly longer than the internodes, bearing prominent auricles at the summit; anthers 1.5-2.8 mm. long ..... 4. *B. latiglumis*

7. Culms with 3-7 nodes; sheaths shorter or longer than the internodes; auricles lacking.

8. Panicle short, mostly 9-12 cm. long, contracted, nodding; anthers 1.5-2.6 mm. long; first glume 3-nerved ..... 5. *B. kalmii*

8. Panicle open, lax, mostly 15-20 cm. long; anthers 2.8-4.6 mm. long; first glume 1-nerved ..... 3. *B. purgans*

2. First glume 3-5-nerved; glumes broadly ovate to elliptical; weedy introduced annual or winter-annual species of waste ground and cultivated fields.

9. Panicle open, pyramidal in well developed individuals, somewhat racemose or reduced to a single spikelet in depauperate ones, the axis exposed, branches spreading or drooping.

10. Lemmas glabrous or scabrous.

11. Lemmas not inflated, ovate or obovate, usually bearing well developed awns or if awnless, then the lemmas individually involute at maturity.

12. Lemmas at maturity involute-margined, thus exposing the rachilla, often short-awned or awnless; sheaths, except sometimes the lowermost, glabrous ..... 7. *B. secalinus*

12. Lemmas at maturity not involute, well imbricated and concealing the rachilla; awns well developed; sheaths pubescent.

13. Spikelets narrowly lanceolate, 3-5 mm. wide when mature; branches of panicle elongated, very slender and flexuous; lower sheaths densely covered with soft white hairs which droop toward the ends and often become matted or tangled ..... 10. *B. japonicus*, var. *porrectus*

13. Spikelets narrowly ovate to oblong 5-8 mm. wide when mature; branches of the panicle ascending to drooping at maturity, not flexuous; lower sheaths sparsely to rather densely covered with straight, spreading to retrorse white hairs ..... 8. *B. commutatus*

11. Lemmas strongly inflated, very broad, awnless or with a short awn-tip, closely imbricated; sheaths pubescent ..... 6. *B. brizaeformis*

10. Lemmas copiously villous; branches of inflorescence flexuous or curled ..... *B. arenarius**

9. Panicle ellipsoid, dense, usually 10 cm. or less long, the branches shorter than the spikelets, which overlap and conceal the axis.

14. Lemmas glabrous ..... *B. racemosus**

14. Lemmas pubescent ..... 9. *B. mollis*

1. Lemmas narrowly lanceolate, with a hard sharp callus and a bifid apex with acuminate teeth.

15. Second glume 10 mm. or less long; lemmas villous, 9-12 mm. long, bearing awns 1-2 cm. long ..... 12. *B. tectorum*

15. Second glume 12-15 mm. long; lemmas scaberulous (rarely hispid), bearing awns 2-3 cm. long ..... 11. *B. sterilis*

1. B. INERMIS Leyss.

Occasional, roadsides, fields and waste places; eastern and southern Pennsylvania. June—July. This European species is cultivated for forage and has occasionally escaped. Var. *divaricatus* Rohlena is a form with very lax, open panicles, the branches flexuous and drooping. It has been collected in Berks County.

2. B. CILIATUS L.

Woods, clearings and meadows; infrequent in the northern half of the state, south in the mountains to Somerset County. July—September. Plants with strongly pubescent middle and upper sheaths have been designated as var. *intonsus* Fernald. Our specimens show a great deal of variation with respect to this character. Forma *laeviglumis* (Scribn.) Wiegand, with glabrous lemmas, is not yet known from Pennsylvania.

Newfoundland to Washington, south to New Jersey, Pennsylvania and Tennessee, Ohio and westward to Nebraska; Rocky Mountain region, westward to the Pacific Coast.

3. B. PURGANS L.

Rocky wooded slopes and roadbanks, common through the state. June—July. Typical *B. purgans* has pubescent sheaths and lemmas. Two minor variants occur among our material. They are:

3A. Forma GLABRIFLORUS Wiegand.

Rare; Susquehanna, Lackawanna, Northhampton, Somerset and Allegheny Counties.

3B. Forma LAEVIVAGINATUS Wiegand.

Sheaths glabrous or the lowermost pubescent. Common.

B. purgans ranges from New Hampshire to Florida, westward to Alberta and Arizona.

4. B. LATIGLUMIS (Shear) Hitch.

Alluvial woods and thickets, mostly along the major rivers and their

tributaries. August—September. Most of our specimens are of the extreme with villous sheaths, forma *incanus* (Shear) Fernald.

Maine to North Carolina, westward to Montana and New Mexico.

5. B. KALMII A. Gray.

Infrequent, rocky wooded slopes; in eastern Pennsylvania as far south as Bucks County; Centre County; Venango County. Mid-June—July.

Maine to western Maryland, westward to South Dakota.

6. B. BRIZAEFORMIS Fisch. & Mey.

This species is sometimes cultivated for ornament and may stray. Our only known Pennsylvania collection is from a quarry near Moselem Springs, Berks County. Introduced from Europe.

7. B. SECALINUS L. Chess.

A common weed of waste ground, roadsides, and grain fields; scattered through the state. Late May—July. Introduced from Europe and now widespread in the United States.

8. B. COMMUTATUS Schrad.

Fields, roadsides, waste ground, dump heaps, almost always on disturbed soil; common throughout the state. Late May—early July. On very sterile soil, reduced forms occur, bearing an inflorescence of one to several spikelets. Introduced from Europe and now widespread in the United States.

9. B. MOLLIS L.

Fields and waste places, eastern Pennsylvania; Centre County; rather rare.

Nova Scotia to North Carolina, westward to South Dakota; Rocky Mountain and Pacific Coast States. Introduced from Europe.

10. B. JAPONICUS Thunb., var. PORRECTUS Hack.

Roadsides and waste ground, occasional in the southern half of the state; Pike and Lackawanna Counties. Late May—early July. Apparently practically all of our material is var. *porrectus*, which has straight awns. Typical *B. japonicus*, with strongly reflexed awns, has very rarely been collected. Var. *porrectus* may be confused with *B. arvensis* L., but that species has anthers 3-4 mm. long and mostly purple spikelets. *B. japonicus* has small anthers, 1-2 mm. long, and usually green or stramineous spikelets. Introduced from the Old World.

11. B. STERILIS L.

Infrequent, roadsides and waste ground; in the eastern counties from Lackawanna County to Philadelphia County; Lancaster, York, Franklin, Bedford and Allegheny Counties. Mid-May—early July.

Massachusetts to South Carolina, westward to Illinois and Arkansas; Colorado and New Mexico to the Pacific Coast States. Introduced from Europe.

12. B. TECTORUM L.

Dry roadsides, waste ground, fallow fields; scattered through the state. May—June, rarely later.

Introduced from Europe and now found throughout most of the United States except the southeastern states.

3. FESTUCA L.

FERNALD, M. L. 1945—Botanical specialties of the Seward Forest and adjacent areas of southeastern Virginia. Rhodora **47**:106-08.

1. Plants slender, annual, with capillary leaves; stamens 1; florets cleistogamous, not opening.

2. First glume 3/4-4/5 as long as the second, 2.3-3.4 mm. long; spikelets 5-13-flowered; awns of the lemmas shorter than the body ....1. *F. octoflora*, var. *tenella*

2. First glume less than ½ (usually 1/4-1/5) as long as the second, 0.8-2.8 mm. long; spikelets usaully 4-5-flowered; awns of lemmas once to twice as long as the body.

3. Lemmas not ciliate .....*F. myuros**

3. Lemmas ciliate.

4. Lemmas ciliate on upper half only .....*F. megalura**

4. Lemmas copiously ciliate from base to tip .....*F. danthonii**

1. Plants perennial, with hard bases; leaves flat or involute; stamens 3; florets opening normally.

5. Leaf blades flat and lax, mostly 3 mm. or more wide.

6. Spikelets 10-20 mm. long; lemmas 5-7 mm. long; panicle narrowly ovoid-cylindrical, contracted and spikelike after flowering, the short branches spikelet-bearing nearly to their bases .....2. *F. elatior*

6. Spikelets 8 mm, or less long; lemmas mostly 3.5-5.0 mm. long; panicle open, lax, nodding, the few usually long branches spikelet-bearing mostly above the middle.

7. Principal lowermost branches of the panicle bearing usually 2-7 spikelets scattered along their outer half; spikelets narrowly ovate, 2-4 mm. broad; leaf blades lax; plants of woods .....3. *F. obtusa*

7. Principal lowermost branches of the panicle bearing 8-20 spikelets clustered near their ends; spikelets broadly ovate, 4-6 mm. broad; plants rather strict; leaf blades firm; plants of thickets, woods margins, and open grassland .....4. *F. paradoxa*

5. Leaf blades very narrow, mostly folded or involute, 2 mm. or less wide.

8. Leaf blades capillary; spikelets 3.6-6.1 mm. long; lemmas 2.4-3.4 mm. long, mostly awnless or with short awn-tips 0.5 mm. or less long .....7. *F. capillata*

8. Leaf blades narrow but not capillary; spikelets 7-12 mm. long; lemmas 4-7 mm. long, with awns usually 0.5 mm. or more long.

9. Innovations arising within the whitish or pale brown persistent sheaths (intravaginal), the plants hence forming dense clumps .....6. *F. ovina*

9. Innovations breaking through the sheaths at their bases and arising separately (extravaginal), often decumbent at the base, forming looser clumps than the preceding; basal sheaths thin, usually reddish brown, soon disintegrating into brown fibers ..... 5. *F. rubra*

1. F. OCTOFLORA Walt., var. TENELLA (Willd.) Fernald.
Vulpia octoflora (Walt.) Rydb., var. *tenella* (Willd.) Fernald

Sterile sandy fields, rock ledges, roadsides, open rocky woods; occasional in southeastern Pennsylvania on the Coastal Plain and Piedmont, rare or overlooked elsewhere in the state. Late May—June, rarely later. The plants dry up early and the spikelets shatter very readily at maturity.

Maine and Quebec to Georgia, westward to southern British Columbia and Colorado, rarely farther south into Arkansas, Texas and California.

2. F. ELATIOR L. Meadow Fescue.

Roadsides, thickets, moist shores, meadows, disturbed soil or waste ground; common throughout the state. Late May—August. Meadow fescue is cultivated for forage and has become widely naturalized. Introduced from the Old World.

3. F. OBTUSA Biehler.

Rocky or alluvial woods and recent clearings; common through the state. Late May—June. The spikelets of this species and the next shatter very readily at maturity.

Quebec to Florida, westward to Manitoba and Texas.

4. F. PARADOXA Desv.
F. shortii Kunth

Moist open ground and thickets; rare in Pennsylvania, known only from Nottingham, Chester County; Lancaster, Lancaster County; and East Sandy, Venango County.

Pennsylvania to Georgia, westward to Iowa and Texas.

5. F. RUBRA L.

Roadsides, waste ground and ballast, dry woods; known from a few scattered localities in the state. June. *F. rubra*, var. *commutata* Gaud., Chewing's Fescue, has been collected as an escape in Centre County. Our specimens of *F. rubra* seem to be mostly introductions.

Northern North America, extending southward to Georgia in the East and Arizona in the West, absent from the prairie and plains country. Eurasia and Africa.

6. F. OVINA L. Sheep Fescue.

Roadsides, dry fields, open woods, waste ground; occasional through the state. May and June. Forma *hispidula* (Hack.) Holmb., with pubescent lemmas, occurs with typical *F. ovina*.

Sheep fescue has been introduced into the northeastern United States but occurs as a native in the western mountains. Eurasia.

7. F. CAPILLATA Lam.

Dry open ground and oak woods; escaped from cultivation; occasional through the state. Late May—June. This species is sometimes used in lawn seed mixtures.

Newfoundland and Maine to North Carolina and Illinois; Oregon. Introduced from Europe.

4. PUCCINELLIA Parl.

FERNALD, M. L. AND C. A. WEATHERBY. 1916. The genus *Puccinellia* in Eastern North America. Rhodora **18**:1-23.

1. Anthers 1.5 mm. or more long ..... *P. maritima**

1. Anthers 1 mm. or less long.

2. Panicle open, the branches mostly floriferous above the middle, naked below, the lower ones becoming strongly reflexed at maturity ..... 1. *P. distans*

2. Panicle open or contracted, the branches floriferous nearly to the base.

3. Spikelets 5-8 mm. long; glumes 1.5 and 2.0-2.5 mm. long; lemmas 3.0-3.5 mm. long ..... *P. rupestris**

3. Spikelets 3.0-5.5 mm. long; glumes 1.0 and 1.5 mm. long; lemmas 2.0-2.5 mm. long ..... *P. fasciculata**

1. P. DISTANS (L.) Parl.

This species has been collected on waste ground in Philadelphia as late as 1915 and may recur here. June.

Quebec to Alaska, southward to Maryland, Michigan, Wisconsin, South Dakota, New Mexico and California. Introduced from the Old World.

5. GLYCERIA R. Br.

1. Spikelets elongate-cylindric, 1-several cm. long.

2. Lemmas acute, much exceeded by the paleas ..... 1. *G. acutiflora*

2. Lemmas obtuse, slightly exceeded by the paleas.

3. Lemmas scaberulous on the nerves, the internerves glabrous; first glume 1.0-2.0 mm. long; second glume 1.9-2.7 mm. long ..... 2. *G. borealis*

3. Lemmas scaberulous over the surface; first glume 2.0-4.0 mm. long; second glume 3.2-5.3 mm. long ..... 3. *G. septentrionalis*

1. Spikelets ovate-oblong, compressed, 7 mm. or less long.

4. Panicle narrow, contracted, the branches strongly ascending.

5. Lemmas about 3.5 mm. long; panicle dense, oblong-cylindric, 15 cm. or less long ..... 4. *G. obtusa*

5. Lemmas 2.0-2.7 mm. long; panicle slender, 15-36 cm. long ..... 5. *G. melicaria*

4. Panicle open, the branches spreading or drooping.

6. Edges of upper sheaths united at least half of their length; culms erect.

7. Spikelets broadly ovate, turgid, 2-5 mm. broad, the lemmas firm, not strongly-nerved.

8. Spikelets 6-10-flowered, mostly 5-7 mm. long .....6. *G. canadensis*
8. Spikelets 3-6-flowered, mostly 3-5 mm. long ....6A. *G. canadensis*, var. *laxa*

7. Spikelets oblong-ovate, 1.2-2.1 mm. broad, the lemmas thin, strongly-nerved.
9. First glume 1 mm. or less long .....7. *G. striata*
9. First glume 1.4 mm. or more long .....8. *G. grandis*

6. Edges of sheaths free and overlapping; low slender plants; culms mostly decumbent and rooting at the lower nodes.
10. Leaf blades 2-8 mm. broad; anthers usually 0.5-1.7 mm. long; grain usually 0.9-1.5 mm. long; blooming mostly in May and June .....9. *G. pallida*
10. Leaf blades 2-3 mm. broad; anthers usually 0.2-0.7 mm. long; grain usually 0.8-1.1 mm. long; blooming mostly in July and August .....9A. *G. pallida*, var. *fernaldii*

1. G. ACUTIFLORA Torr.

Swamps, muddy shores, shallow water; uncommon in the mountains of Lackawanna, Pike, Monroe and Potter Counties, and from Centre to Bedford Counties; Butler County; on the Coastal Plain and Piedmont in Bucks, Montgomery and Philadelphia Counties. Late May—August.

New Hampshire to Delaware, westward to Michigan, Indiana and Tennessee; Asia.

2. G. BOREALIS (Nash) Batchelder.

Shallow water and marshy shores; rare; Pike, Wayne, Susquehanna, Monroe and Centre Counties. July.

Newfoundland to southern Alaska, south to Pennsylvania, westward to Illinois, Iowa, South Dakota, New Mexico, Arizona and California.

3. G. SEPTENTRIONALIS Hitch.

Wet meadows, marshes, ditches and water holes, margins of streams, often in shallow water; common on the Piedmont and Coastal Plain in southeastern Pennsylvania, occasional elsewhere in the southern half of the state and extending northward in the Beaver River drainage to Crawford County. Late May—August; rarely later.

Quebec to South Carolina, westward to Minnesota and Texas.

4. G. OBTUSA (Muhl.) Trin.

Rare, in swamps near Tobyhanna, Monroe County, and along Cobbs Creek and Crum Creek in Delaware County, on the Coastal Plain. July—August.

The occurrence of this species, which is elsewhere confined mostly to the Coastal Plain, in the Monroe County bogs, is paralleled by the occurrence in the same general area of such other Coastal Plain plants as *Lygodium palmatum* (Bernh.) Sw., *Carex collinsii* Nutt., *C. longii* Mackenzie, *Clethra alnifolia* L., *Nymphoides lacunosum* (Vent.) Fernald. Porter records this species from Clearfield County, and there is an old specimen, collected by J. M. McMinn and bearing Porter's label, in the Herbarium of the Academy

of Natural Sciences of Philadelphia, bearing the data "Wet meadow, Clearfield County". If this label is correct, this specimen represents a remarkable inland extension of the range of this coastal species.

Nova Scotia to North Carolina, mostly near the coast.

5. G. MELICARIA (Michx.) F. T. Hubb.

Wet thickets and woods, banks of streams, swamps; common throughout the state, but apparently lacking from the Coastal Plain. Mid-June—early September, rarely later.

New Brunswick to Delaware and Ohio, south in the mountains to North Carolina and Tennessee .

6. G. CANADENSIS (Michx.) Trin.

Marshes and swamps, wet woods, stream banks, alluvial lowlands; fairly common through the state. Late June—early September.

Newfoundland to Maryland and West Virginia, westward to Minnesota and Illinois.

6A. G. CANADENSIS, var. LAXA (Scribn.) Hitch.

Found in similar habitats, and intergrading with typical *G. canadensis;* mountains of northeastern Pennsylvania, rare elsewhere in the state.

Nova Scotia to Pennsylvania, Maryland, West Virgina and Michigan.

7. G. STRIATA (Lam.) Hitch.

Wet meadows, ditches, along streams, alluvial woods, marshes and swamps; common through the state. Late May—August.

This species is rather variable. A northern variant, not known definitely from Pennsylvania, having a rather strict panicle and purplish spikelets, is var. *stricta* (Scribn.) Fernald. Woodland forms have small, very lax and delicate panicles of small spikelets.

Newfoundland to British Columbia, southward throughout the United States.

8. G. GRANDIS S. Wats.

Shallow water or wet ground in swamps, marshes or wet meadows; northern Pennsylvania, common on the Appalachian Plateau; rare in Schuylkill, Bucks, Philadelphia and Bedford Counties. Mid-June—July.

Prince Edward Island to Alaska, southward to Tennessee and Indiana, westward to Nebraska, New Mexico, Nevada and Oregon.

9. G. PALLIDA (Torr.) Trin.

Swamps, marshes, water holes and ditches; eastern Pennsylvania, from Pike and Luzerne Counties south to Berks and Delaware Counties; in the mountains from Centre County to Bedford County; Butler County; not common. May—June, rarely later. *G. pallida* intergrades very freely with the following.

Maine to North Carolina, westward to Wisconsin and Missouri.

9A. G. PALLIDA, var. FERNALDII Hitch.

G. fernaldii (Hitch.) St. John

Margins of lakes and streams; rare and confined to the northern half of the state, from Wayne and Monroe Counties westward to Lawrence County.

Newfoundland to Pennsylvania, westward to Michigan, Wisconsin and Minnesota.

6. POA L.

1. Lemmas with a cottony web at the base.
2. Lemmas pubescent at least on the keel.
3. Marginal nerves of lemmas pubescent.
4. Plants with prominent creeping rhizomes.
5. Culms strongly flattened and keeled (nodes keeled in pressed specimens); lemmas usually rounded at the apex; culms without basal tufts of long leaves, forming a very loose turf ..... 2. *P. compressa*
5. Culms terete (nodes terete or nearly so in pressed specimens); lemmas acute; culms with long tufted basal leaves, forming a rather dense turf or clump.
6. Anthers 1.0-1.8 mm. long; lower panicle branches mostly in 5s; lemmas 2.4-3.6 mm. long ..... 3. *P. pratensis*
6. Anthers 2.0-3.5 mm. long; lower panicle branches mostly paired; lemmas 3.5-5.4 mm. long ..... 4. *P. cuspidata*
4. Plants tufted, lacking rhizomes (old clumps sometimes stooling out or the plants with decumbent culms, especially in wet places).
7. Upper ligules 2.5-7.0 mm. long; internerves of lemmas glabrous.
8. Lemmas greenish-yellow, the intermediate nerves prominent; sheaths mostly scaberulous ..... 5. *P. trivialis*
8. Lemmas green, usually purple or bronzy at the tip, the intermediate nerves obscure; sheaths smooth ..... 12. *P. palustris*
7. Upper ligules 2 mm. or less long (rarely longer in *P. sylvestris* with pubescent internerves).
9. Panicle branches in whorls of 3 or more.
10. Internerves of lemmas pubescent; lemmas and glumes rounded to an acute apex; lower panicle branches reflexed at maturity..... ..... 9. *P. sylvestris*
10. Internerves of lemmas glabrous; glumes narrow, acuminate; lower panicle branches not reflexed ..... 11. *P. nemoralis*
9. Panicle branches paired ..... 10. *P. paludigena*
3. Marginal nerves of lemmas glabrous.
11. Upper ligules 3-7 mm. long; sheaths mostly scaberulous; some of the panicle branches usually short and floriferous nearly to their bases; intermediate nerves of lemmas conspicuous ..... 5. *P. trivialis*
11. Upper ligules 0.5-2.0 mm. long; sheaths nearly smooth; branches of panicle elongated, spreading, naked near the base; intermediate nerves of the lemmas obscure ..... 6. *P. alsodes*

2. Lemmas glabrous except for the web.
12. Lemmas acute, rather thin, with prominent nerves .....8. *P. saltuensis*
12. Lemmas obtuse, rather coriaceous, with obscure nerves .....7. *P. languida*
1. Lemmas not webbed at the base.
13. Lemmas pubescent on the nerves and lower internerves; plants perennial, 30-60 cm. tall; uppermost leaf blade 5-15 cm. long .....13. *P. autumnalis*
13. Lemmas pubescent on the nerves, the internerves glabrous; plants mostly annual, low, usually 5-20 cm. tall; uppermost leaf blade 1-5 cm. long ..... 1. *P. annua*

1. P. ANNUA L.

Waste ground, lawns, paths, roadsides, moist soil along streams or about springs, open woods; common through the state. With us, this plant flowers from April to September. Most of the plants flower from April to June, but a few bloom during July and August, and a second peak in flowering occurs in September. Lax, slender aquatic forms, rooting at the lower nodes, occur occasionally. This species is a nuisance in lawns, where it dies out at the advent of hot weather, leaving bare patches.

Newfoundland and Labrador southward; throughout the United States. Introduced from Europe.

2. P. COMPRESSA L. Canada Bluegrass.

Roadsides, waste ground, fields and meadows, open woods, especially on sterile or dry soils; common throughout the state. Mid-May—September. Usually this species begins to bloom a week or two later than *P. pratensis* in the same localities. It is sometimes cultivated for forage.

Newfoundland to Georgia, westward to Alaska and California. Introduced from Europe.

3. P. PRATENSIS L. Kentucky Bluegrass.

Roadsides, fields and meadows, waste ground, open woods; common throughout Pennsylvania. Late April—July. Extensively cultivated as a lawn and forage grass and now widely naturalized.

Throughout the United States; introduced from Europe.

4. P. CUSPIDATA Nutt.

Rocky banks and open dry wooded hillsides; occasional across the southern one third of the state and extending as far north as Butler County. Blooming mostly in April and early May; the earliest of the native species of *Poa*.

New Jersey and Ohio to Georgia and Tennessee.

5. P. TRIVIALIS L.

Swamps and wet meadows, alluvial woods, wet ground along streams, springy or seepy places in woods; occasional through the state. Mid-May—June. Cultivated for lawns and forage and rather freely escaping.

Newfoundland to Virginia, westward to South Dakota and Kentucky; Pacific Coast States. Introduced from Europe.

6. P. ALSODES A. Gray.

Moist cool rocky or alluvial woods; northern Pennsylvania, extending southward to Montgomery and York Counties in the eastern portion of the state and along the mountains to Bedford, Somerset and Fayette Counties; Allegheny County. Mid-May—June.

Maine to Minnesota, southward to Delaware and Ohio and in the mountains to Tennessee and North Carolina.

7. P. LANGUIDA Hitch.

Rare, in open, dry woods; late May. This woodland *Poa* is known at present from Pennsylvania only by the few cited collections, but presumbably is to be found elsewhere in the northeastern counties. Older reports of this species (as *P. debilis* Torr.) from Monroe County by Porter and others are based on specimens of *P. saltuensis,* to which it is very closely allied.

LACKAWANNA COUNTY: 1 mi. e.n.e. of Elmhurst, June 25, 1946. *S. L. Glowenke 6707.* P.; 2 mi. w.s.w. of Chinchilla, June 23, 1946. *S. L. Glowenke.* P.

CARBON COUNTY: Woods, near brook, 2¼ mi. n.w. of Trauchsville, alt. 880 ft., May 30, 1938. *Hans Wilkens 5486-a.* P. BEDFORD COUNTY: Open woods, alt. 1340 ft., 1¾ mi. s.s.w. of King, May 27, 1945. *D. Berkheimer 5898.* P., and *5895.* P.

Newfoundland to Minnesota, southward to Pennsylvania, Kentucky, Illinois and Iowa.

8. P. SALTUENSIS Fernald & Wiegand.

Woods, occasional in the mountains of northern Pennsylvania, south along the mountains to Franklin, Bedford and Somerset Counties. End of May—June.

Newfoundland and Quebec to Maryland, westward to Minnesota.

9. P. SYLVESTRIS A. Gray.

Rich woods, southern Pennsylvania, extending from Berks and Montgomery Counties westward across the state, and as far north as Erie County in the western portion. Mid-May—July.

New York to Florida, westward to Wisconsin and Texas.

10. P. PALUDIGENA Fernald & Wiegand.

Boggy woods; rare; in the mountains of Luzerne, Carbon, Sullivan, and Bedford Counties; Berks, Chester and Lancaster Counties; Crawford County.

New York and Pennsylvania, westward to Wisconsin and Illinois.

11. P. NEMORALIS L.

Dry woods, railroad cuts; rare; Monroe, Northampton, Berks and Montgomery Counties. June.

Newfoundland to Delaware, westward to Minnesota; Oregon. Introduced from Europe.

12. P. PALUSTRIS L.

Moist woods and thickets, swamps, banks of streams, mostly in the mountains in the northern half of the state, extending southward in the mountains to Bedford County; Northampton, Berks and Delaware Counties. Mid-June—early August.

Newfoundland and Quebec; Maine to Virginia and westward across the continent; New Mexico; Eurasia.

13. P. AUTUMNALIS Muhl.

Woods; rare, known only from two stations on the Piedmont, cited below. BERKS COUNTY: Trap Rock Station, *Hans Wilkens 89*. A. PHILADELPHIA COUNTY: Wissahickon Ravine, below Thorp's Lane, June 3, 1908. *S. S. Van Pelt*. P., A.

New Jersey to Florida, westward to Michigan, Illinois and Texas.

7. BRIZA L.

1. Ligule of uppermost leaf 1.5 mm. or less long, truncate; glumes shorter than the contiguous lemmas ..... 1. *B. media*

1. Ligule of uppermost leaf 4 mm. or more long, acute; glumes longer than the contiguous lemmas ..... *B. minor**

1. B. MEDIA L.

Adventive; known from only the following collection in Pennsylvania. BERKS COUNTY: Dry grassy slope 1¼ mi. s.e. of Fleetwood, July 11, 1937. *Hans Wilkens 5225*. P.

Vermont to Connecticut and Pennsylvania, westward to Ontario and Michigan. Introduced from the Old World and sometimes cultivated for ornament.

8. ERAGROSTIS Beauv.

FERNALD, M. L. 1945—Botanical specialties of the Seward Forest. Contrib. Gray Herbarium 156. Rhodora **47**:108; LONG, BAYARD. 1919—The specific characters of *Eragrostis peregrina* and its two allies. Ibid. **21**:133-40; WIEGAND, K. M. 1917—A new species of *Eragrostis* of the Old World and North America. Ibid. **19**:93-96.

1. Plants prostrate, forming mats, rooting at the lower nodes, growing on wet mud or near water ..... 1. *E. hypnoides*

1. Plants not prostrate and mat-forming, not rooting at the nodes (culms sometimes decumbent at the base); plants of moist or dry ground.

2. Spikelets with 2-4 (-5) florets.

3. Pedicels of lateral spikelets elongated, 2-many times as long as the spikelet; panicle very diffuse, making up 2/3 or more of the height of the erect plant ..... 2. *E. capillaris*

3. Pedicels of lateral spikelets short, seldom more than twice the length of the spikelet; panicle open, not diffuse, about half the total length of the sprawling plants ..... 3. *E. frankii*

2. Spikelets with 6-many florets (rarely 5 florets in depauperate individuals).

4. Plants with conspicuous tufts of white hairs in the throats of the sheaths and on pulvini of the main panicle branches; spikelets reddish; exposed keels of the paleas hispid-ciliate with short, stiff spinules; perennials, with hard, knotty bases ..... 9. *E. spectabilis*

4. Plants lacking conspicuous tufts of white hairs (a few auricular and pulvinar hairs present in most species); keels of paleas mostly concealed, not hispid-ciliate; tufted, shallow-rooted annuals with soft bases.

5. Plants with conspicuous glandular dots on the keels of the lemmas and branches of the panicles.

6. Spikelets 2.5-3.5 mm. wide ..... 7. *E. cilianensis*
6. Spikelets 1.3-2 mm. wide ..... 8. *E. poaeoides*

5. Plants lacking glandular dots.

7. Sheaths bearing long auricular hairs at their summits.

8. Spikelets at maturity diverging strongly from the panicle branches.

9. Panicle open, the branches capillary, naked for 1-several cm. at the base; spikelets 0.7-1.4 mm. wide; first glume 0.6-1.0 mm. long; lateral nerves of lemmas obscure ..... 4. *E. pilosa*

9. Panicle rather dense, the branches floriferous nearly to their base, not capillary; spikelets 1.3-2 mm. wide; first glume 1.1-1.6 mm. long; lateral nerves of lemmas prominent ..... 8. *E. poaeoides*

8. Spikelets mostly closely appressed to the panicle branches; paleas persistent on the rachilla ..... 5. *E. pectinacea*

7. At least the upper sheaths (usually all) lacking auricular hairs; panicle rather dense, the lower branches usually single, bearing 11-40 spikelets; paleas deciduous with the lemmas from the rachilla ..... 6. *E. multicaulis*

1. E. HYPNOIDES (Lam.) B.S.P.

Occasional on wet shores and mud flats, mostly along the Delaware, Susquehanna and Ohio Rivers and their larger tributaries; pond holes in woods; probably through the state. End of June—September.

Quebec to Florida, westward to North Dakota, Colorado and Texas; Idaho, Utah and the Pacific Coast States.

2. E. CAPILLARIS (L.) Nees.

Dry thickets, open woods, roadsides and waste ground, often on sandy soil; common in southeastern Pennsylvania, on the Piedmont; scattered elsewhere in the remainder of the state and mostly lacking from the higher portions of the Appalachian Plateau. Late July—early October.

Maine to Georgia, westward to Wisconsin, Kansas and Texas.

3. E. FRANKII C. A. Mey.

Rare, moist river shores along the Delaware and its larger tributaries from Easton southward; along the Susquehanna in Wyoming, Dauphin, York and Lancaster Counties; Franklin and Bedford Counties; Warren, Westmoreland and Allegheny Counties in the Allegheny drainage; Erie County. September.

New Hampshire to Florida, westward to Minnesota, Kansas and Mississippi.

4. E. PILOSA (L.) Beauv.

Rare; roadsides, ballast, gardens, mostly on the Coastal Plain and Piedmont,

southeastern Pennsylvania; Lackawanna, Pike, Franklin, Bedford, Somerset and Green Counties. Late July—September.

Massachusetts to Florida, westward to Michigan, Nebraska, Colorado and Texas; California. Introduced from Europe.

5. E. PECTINACEA (Michx.) Nees.

Common, waste ground, roadsides, river shores; through the state. July—early October.

Maine to Florida, westward to North Dakota, New Mexico and Arizona; Washington and Idaho.

6. E. MULTICAULIS Steud.

E. peregrina Wiegand

Occasional along roads and railroads, waste ground, streets and sidewalks, about habitations; eastern Pennsylvania as far north as Lackawanna, Wyoming and Northumberland Counties, more common in the Coastal Plain and Piedmont; Bedford and Allegheny Counties; Presque Isle, Erie County. July—October.

Maine to Maryland, westward to Wisconsin; Oregon. Introduced from the Old World.

7. E. CILIANENSIS (All.) Link. Stinkgrass.

Fairly common; streets and roadsides, waste ground, fields and gardens; through the state, more common in the southeastern portion and mostly lacking from the higher portions of the Appalachian Plateau. July—October. The fresh plants often have a strong, musty odor.

Throughout the United States; introduced from Europe.

8. E. POAEOIDES Beauv.

Waste ground, along roads and railroads; fairly common in the Delaware and Susquehanna drainages as far north as Wyoming and Lackawanna Counties; Susquehanna, Bradford, Tioga, Elk, Bedford and Washington Counties. Late June—September.

Vermont to Georgia, westward to Iowa and Texas; Arizona and California. Introduced from Europe.

9. E. SPECTABILIS (Pursh) Steud.

Dry open, often sandy ground, roadsides, serpentine barrens; eastern Pennsylvania from Pike, Lackawanna, Wyoming and Sullivan Counties to Delaware and Lancaster Counties; Bedford and Allegheny Counties; fairly common on the Coastal Plain and Piedmont, rare elsewhere. Mid-June—mid-October.

Maine to Florida, westward to Minnesota, New Mexico and Arizona.

9. MOLINIA Schrank

DIX, W. L. 1945—Will the stowaway, *Molinia caerulea*, become naturalized? Bartonia **23**:41-42.

M. CAERULEA (L.) Moench.

This is an European species, apparently introduced with grass seed. Mr. Dix has collected it in an abandoned field in Wayne County, and it has also been found occurring as a ballast waif in Philadelphia.

Maine to Pennsylvania and New Jersey.

10. DISTICHLIS Raf.

D. SPICATA (L.) Greene.

This is a plant of the coastal salt-marshes, adventive around Philadelphia on ballast ground and rubbish-heaps. Mr. Bayard Long has collected it as recently as 1943 in Upper Darby, Delaware County.

Along the Atlantic and Gulf Coasts from Nova Scotia to Florida and Texas; Cuba; Pacific Coast from British Columbia to Mexico; Pacific Coast to South America.

11. UNIOLA L.

1. Panicle open, the branches drooping; spikelets 2-3 cm. long, 8-12-flowered; large leaf blades 1.5-2.5 cm. wide ..... 1. *U. latifolia*

1. Panicle slender, strict, the short branches ascending; spikelets usually 5-8 mm. long, 3-4-flowered; leaf blades 3-7 mm. wide ..... 2. *U. laxa*

1. U. LATIFOLIA Mich.

River banks, alluvial or rocky woods, along the lower Susquehanna River in southern Lancaster County and along Octoraro Creek, southern Chester County; Allegheny County, where probably cultivated. July—September.

New Jersey to Florida, westward to Kansas and Texas.

2. U. LAXA (L.) B.S.P.

Rare; Delaware and Philadelphia Counties, on the Coastal Plain. August—September.

Coastal Plain, from Long Island to Florida and Texas and in the interior to Kentucky and Arkansas.

12. DACTYLIS L.

D. GLOMERATA L. Orchard Grass.

Roadsides and waste places, fields, moist woods, river shores, throughout the state. May—July. Orchard grass was introduced from Europe as a forage grass but has become thoroughly naturalized.

Newfoundland to Alaska, southward throughout the United States.

13. CYNOSURUS L.

C. CRISTATUS L.

Rare, in lawns. Bucks County to Philadelphia and Delaware Counties; Union County; Adams County. June—August.

Newfoundland to Virginia, westward to Michigan; Washington, Idaho, Oregon. Introduced from Europe.

14. PHRAGMITES Adans.

P. COMMUNIS Trin. Reed.

P. maximus of Authors, not *Arundo maxima* Forsk.

Tidal and inland marshes, alluvial flats, wet meadows, rarely on dry

embankments; common in marshes along the Delaware Estuary in Delaware County, rare elsewhere in the state; known from Monroe, Schuylkill, Berks, Chester, Bedford, Crawford and Erie Counties. Late July—September.

Fernald, in *Rhodora* **34**:211 (1932) has designated our American plants of this species as var. *berlandieri* (Fourn.) Fernald, based upon a type from Texas. Until all the variations of this very wide ranging species are studied, I prefer to maintain it undivided.

Nova Scotia to British Columbia, southward through the United States but lacking from the southeastern states except Florida; Mexico; South America and the other continents.

15. MELICA L.

BOYLE, W. S. 1945—A cyto-taxonomic study of the North American species of *Melica*. Madrono **8**:1-26.

M. NITENS (Scribn.) Hitch.

Rare; steep rocky slopes; Lancaster, Perry and Bedford Counties, along the lower Susquehanna River and its tributaries; and in Somerset County, along the Casselman River. End of May—mid-July.

Pennsylvania and Virginia, westward to Wisconsin, Nebraska, Texas, New Mexico and Arizona.

16. SCHIZACHNE Hack.

S. PURPURASCENS (Torr.) Swallen.

Rich or dry woods, road banks, on the Appalachian Plateau. All of our specimens are from the northern third of the state with the exception of one from Cambria County. This is a northern species, reaching its southern limit in Pennsylvania. Late May—June.

Newfoundland to Alaska, south to northern Pennsylvania, Kentucky, Minnesota and New Mexico.

17. TRIODIA R. Br.

T. FLAVA (L.) Smyth. Purple Top.

Dry sandy fields, open woods, roadsides, banks of streams; fairly common in eastern and southern Pennsylvania, in the Coastal Plain, Piedmont and Ridge and Valley Provinces; absent from the higher parts of the Appalachian Plateau, but occurring in the Monongahela watershed. Late July—September.

New Hampshire to Florida, westward to Nebraska and Texas.

18. TRIPLASIS Beauv.

T. PURPUREA (Walt.) Chapm.

Dry open sandy soil, beaches and dunes. This species has been collected on the Coastal Plain in Bucks and Philadelphia Counties, where it occurs probably only as a waif brought in from the New Jersey pine barrens area. It is also known from the sandy beaches along Lake Erie in Erie County, but is absent from the remainder of the state. August—September.

New Hampshire to Georgia, westward to Minnesota, Colorado and Texas.

19. AGROPYRON Beauv.

FERNALD, M. L. 1933—Contrib. Gray Herbarium 101. *Agropyron*, section *Goulardа* in Eastern North America. Rhodora **35**:161-185.

1. Plants rhizomatous; anthers 3-6 mm. long; spikelets not readily disarticulating, mostly falling from the rachis whole.
   2. Glumes herbaceous, flexible; leaf blades flat and lax, pubescent above, finely nerved ..... 1. *A. repens*
   2. Glumes rigid, coriaceous; leaf blades mostly involute, stiff, glaucous, glabrous, coarsely-nerved ..... 2. *A. pungens*
1. Plants not rhizomatous; anthers 1.0-2.5 mm. long; spikelets readily disarticulating at maturity, the glumes persistent on the rachis.
   3. Awns less than half as long as the lemmas, or lacking ..... 3A. *A. trachycaulum*, var. *novae-angliae*
   3. Awns nearly as long as the lemmas, or longer.
      4. Glumes 6-12 mm. long; awns of lemmas 7-20 mm. long ..... 3B. *A. trachycaulum*, var. *glaucum*
      4. Glumes 12-18 mm. long; awns of lemmas 10-40 mm. long ..... 3C. *A. trachycaulum*, var. *unilaterale*

1. A. REPENS (L.) Beauv. Quackgrass.

Waste ground, roadsides and streets, fields and meadows; a pernicious weed, common throughout Pennsylvania. Late May—July, rarely later.

Newfoundland to southern Alaska, southward; through the United States except the southeastern states and Arizona. Introduced from the Old World.

A. repens is an extremely variable species. Names have been given to numerous awned or awnless, green or glaucous, glabrous or variously pubescent variants. Since the final application of all of these names awaits the critical study of much European material, they are not given here.

2. A. PUNGENS (Pers.) R. & S.

This species is definitely known from Pennsylvania only by the following specimen, undoubtedly a waif, but has been reported in recent years to persist in eastern Philadelphia, and should be sought there.

PHILADELPHIA COUNTY: Girard Point, Philadelphia, September, 1896. *Herb. Joseph Crawford.* A.

Nova Scotia to Massachusetts; Oregon.

3A. A. TRACHYCAULUM (Link) Steud., var. NOVAE-ANGLIAE (Scribn.) Fernald.

Rare; open woods and roadsides in the mountains of Luzerne, Carbon, and Huntingdon Counties.

Labrador and Newfoundland to northern Pennsylvania, westward to Michigan, Wisconsin, Nebraska, Colorado and Nevada.

3B. A. TRACHYCAULUM, var. GLAUCUM (Pease & Moore) Malte.

Road banks, thickets, rocky woods, sandy oak barrens; in the mountains of Wayne, Lackawanna, Luzerne, Pike, Monroe, Centre and Somerset Counties; uncommon. Mid-June—July.

Newfoundland to northern Pennsylvania, westward to southern British Columbia, Michigan, Wisconsin, Minnesota, Nebraska, Colorado, Nevada and California.

3C. A. TRACHYCAULUM, var. UNILATERALE (Cassidy) Malte.

This variety is known in Pennsylvania only as a waif on a slag dump at Allentown.

St. Lawrence Valley, Quebec and Ontario; western New York, westward to British Columbia, south to Wisconsin, Iowa, South Dakota, Colorado, Nevada and Oregon.

20. TRITICUM L.

T. AESTIVUM L. Wheat.

Wheat sprouts from scattered seed on waste ground and roadsides, and may be found nearly everywhere wheat is grown. It never maintains itself.

21. AEGILOPS L.

1. Glumes bearing one long awn and a short lateral tooth ..... 1. *A. cylindrica*
1. Glumes bearing three awns ..... 2. *A. triuncialis*

1. A. CYLINDRICA Host.

Known in Pennsylvania only by the following collection.

DELAWARE COUNTY: Well established in a lumber yard at 63rd St. and Market St., Upper Darby, June 5, 1942. *W. H. Wagner* and *Carroll Wood 1977*. P., A.

Wheat fields and waste places, Missouri, Kansas, Oklahoma, Colorado, New Mexico; New York. Introduced from Europe.

2. A. TRIUNCIALIS L.

Collected once at West Chester, where it occurred with *Hordeum leporinum*. These two species may have been introduced from the West. The only other report of this species in the United States is from California. Introduced from Europe.

CHESTER COUNTY: West Chester, near Kift's greenhouses, June 13, 1925. *Wm. Trimble*. A.

22. SECALE L.

S. CEREALE L. Rye.

Rye may possibly persist briefly after cultivation, and sometimes sprouts from scattered seed.

23. ELYMUS L.

FERNALD, M. L. 1933—Types of some American species of *Elymus*. Rhodora **35**: 187-198; WIEGAND, K. M. 1918—Some species and varieties of *Elymus* in eastern North America. Ibid. **20**:81-90.

Note: Measurements refer to spikelets near the middle of the spike.

1. Awns straight when mature and dry; palea of lower floret 5-9 mm. long.

2. Glumes 1-2 mm. broad above, usually strongly indurate and bowed-out above the base.

3. Glumes and lemmas awned.

4. Glumes 1-2.7 cm. long; lemmas 1-3 cm. long.

5. Glumes and lemmas glabrous or scabrous ..... 5. *E. virginicus*

5. Glumes and lemmas hirsute ..... 5A. *E. virginicus*, f. *hirsutiglumis*

4. Glumes 2.7-4 cm. long; lemmas mostly 3.5-4.5 cm. long ..... 5C. *E. virginicus*, var. *glabriflorus*

3. Glumes and lemmas awnless or merely short awn-tipped ..... 5B. *E. virginicus*, f. *submuticus*

2. Glumes 0.4-0.8 mm. broad, not evidently bowed-out above the base.

6. Leaf blades and sheaths glabrous; spikelets 2-4-flowered; glumes and lemmas scabrous; palea of lower floret 7-8 mm. long; rachis joints 3-8 mm. long ..... 4. *E. riparius*

6. Leaf blades villous above; sheaths villous to glabrous; spikelets 1-2-flowered; palea of lower floret 5-7 mm. long; rachis joints 1.5-3.0 mm. long.

7. Glumes and lemmas hirsute ..... 1. *E. villosus*

7. Glumes and lemmas glabrous or slightly hispid ..... 1A. *E. villosus*, f. *arkansanus*

1. Awns divergently curled when mature and dry; palea of lower floret 9-15 mm. long.

8. Glumes usually 15-20 mm. long; spikelets 4-7-flowered; inflorescences lax; the 10-18 culm blades lax and flat, 13-20 mm. broad, the larger ones with 60-100 nerves ..... 3. *E. wiegandii*

8. Glumes usually 20-35 mm. long; spikelets 2-5-flowered; inflorescences dense; the 4-9 culm blades firm and often involute, 5-15 mm. broad; the larger ones with 20-40 (-70) nerves ..... 2. *E. canadensis*

1. E. VILLOSUS Muhl.

Stream banks, alluvial thickets, marshes, damp woods; common on the Coastal Plain and Piedmont in southeastern Pennsylvania, uncommon elsewhere in the eastern and southern portions and apparently mostly lacking from the northern half of the state. Mid-June—early August.

Vermont to North Carolina and Alabama, westward to North Dakota, Wyoming and Texas.

1A. E. VILLOSUS, f. ARKANSANUS (Scribn. & Ball) Fernald.

Uncommon, eastern and southern Pennsylvania, mostly on the Piedmont; Potter County.

2. E. CANADENSIS L. Canada Wild Rye.

Alluvial thickets, rocky woods and cliffs, scattered through the state, espe-

cially along the Delaware, Susquehanna and Ohio Rivers and their larger tributaries. End of July—early September.

Quebec to North Carolina and Mississippi, westward to Alaska and northern California.

E. canadensis is a variable species. A trivial glaucous form has been designated as f. *glaucifolius* (Muhl.) Fernald. Rare specimens from Pennsylvania may have glabrous spikelets but are otherwise typical. They are not referable to the very different var. *brachystachys* (Scribn. & Ball) Farwell, of the Southwest.

3. E. WIEGANDII Fernald.

Rare; alluvial thickets along the Susquehanna River in Susquehanna, Bradford and Wyoming Counties; Honesdale and White Oak Pond, Wayne County. August—September.

Gaspe County, Quebec, to Lake St. John, southward to northern Pennsylvania.

4. E. RIPARIUS Wiegand.

Stream banks, alluvial woods, fields and meadows, marshes, rocky woods throughout the state. This is our most common and widely distributed wild rye. July—mid-September. A small percentage of our specimens are intermediate between *E. riparius* and *E. virginicus* in a number of respects. These specimens have the glumes broader than typical for *E. riparius*, and of firmer texture, with the bases somewhat indurate but not as much so as in *E. virginicus*. The inflorescences tend to be shorter than typical in *E. riparius*, and have a greater tendency to be included at the base. Cultural and genetic studies on such plants might well give better indications as to their nature.

Quebec to North Carolina, westward to Michigan and Indiana; Arkansas.

5. E. VIRGINICUS L. Virginia Wild Rye.

Banks of streams, alluvial thickets, marshes, rich woods, waste ground: fairly common through the state, especially along the major rivers and their tributaries. Mid-June—mid-September.

Newfoundland to Florida, westward to Alberta and Arizona.

This is a highly polymorphous species; the following variants may be recognized among our specimens.

5A. E. VIRGINICUS, f. HIRSUTIGLUMIS (Scribn.) Fernald.

This form has the same range and grows in habitats similar to those of typical *E. virginicus* and is nearly as common as the latter in Pennsylvania.

5B. E. VIRGINICUS, forma **submuticus** (Hooker) comb. nov.

E. virginicus L., *β submuticus* Hooker, Flor. Bor.-Am. **2**:255 (1840)

Rare; Lackawanna, Schuylkill and Allegheny Counties.

This rare awnless variant of the species, lacking other morphological distinctions or a different range, does not merit more than formal recognition.

5C. E. VIRGINICUS, var. GLABRIFLORUS (Vasey) Bush.

This variety is common along the Atlantic Coast in New Jersey. In Pennsylvania, it is represented only by the specimens cited below, although some material from the Coastal Plain in Delaware County approaches this extreme.

LANCASTER COUNTY: Haines Station, August 15, 1933. *E. M. Gress.* P., C.; Columbia, July 11, 1919. *E. M. Gress.* C. (This is the form with pubescent spikelets, f. *australis* (S. & B.) Fernald.)

24. HYSTRIX Moench.

1. Lemmas glabrous ..... 1. *H. patula*
1. Lemmas pilose ..... 1A. *H. patula*, var. *bigeloviana*

1. H. PATULA Moench. Bottlebrush.

Woods and thickets, banks of streams, roadsides; common through the state. Mid-June—early August. One or both of the glumes are occasionally developed on some or all of the spikelets of an inflorescence.

A specimen collected by Leidy at Robinson's Knoll, Fairmount Park, Philadelphia, in July 1862, is apparently a hybrid of *Hystrix* with a species of *Elymus*. The glumes are developed, as in the latter genus, but are acicular, nerveless, and much narrowed above the base. The florets are sterile. Two other specimens, collected by Leidy at the same time and place, are also in the Herbarium of the University of Pennsylvania. They are *Hystrix patula* and *Elymus virginicus*.

Nova Scotia to Georgia, westward to North Dakota and Arkansas.

1A. H. PATULA, var. BIGELOVIANA (Fernald) Deam.

Rocky or alluvial woods, apparently rare; eastern Pennsylvania as far south as Philadelphia County; Allegheny and Washington Counties. Most of the stations for this variety are along the Delaware River.

Nova Scotia to Virginia, westward to Ohio, Indiana and Wisconsin.

25. HORDEUM L.

1. Rachis of the spikes disarticulating at maturity, the spikelets falling attached to the joints; lemma of central spikelet of each group usually less than 8 mm. long.

2. At least some of the glumes ciliate; spikes quadrate, usually included at the base in the inflated uppermost sheath ..... 3. *H. leporinum*

2. Glumes not ciliate; spikes usually exserted; upper sheath not inflated.

3. Awns very slender, mostly 5-8 cm. long; plants perennial ..... 1. *H. jubatum*

3. Awns less than 2 cm. long; plants annual.

4. Glumes of the central spikelet and inner glumes of the lateral spikelets strongly dilated above the base; spikes narrow-cylindric, usually 4-8 times as long as wide ..... 2. *H. pusillum*

4. Glumes setaceous, not dilated above the base; spikes short-cylindric, about twice as long as wide ..... *H. hystrix*[8]

1. Rachis of the spikes not disarticulating; lemma of the central spikelet of each group over 1 cm. long ..... 4. *H. vulgare*

1. H. JUBATUM L. Squirrel-tail.

Old fields, roadsides and railroad embankments, waste ground; sparingly

introduced in eastern Pennsylvania, from Wayne County to Bradford County and southward, mostly on the Coastal Plain and Piedmont; Bedford, Allegheny, Erie and Lawrence Counties. Late June—August.

Newfoundland to Virginia, westward to Alaska, Texas and California; probably mostly introduced in the East.

2. H. PUSILLUM Nutt. Little Barley.

Rare; Bucks and Bedford Counties, probably adventive from the West. The Bedford County station, discovered by Dr. Berkheimer, has maintained itself for at least four years, from 1942 to 1946. May.

Maine; Pennsylvania to Florida and westward to the Pacific Coast.

3. H. LEPORINUM Link.

This species was collected many years ago on ballast and around the Centennial Grounds in Philadelphia. More recently, the plant was found at West Chester, where it occurred with *Aegilops triuncialis*, another introduced species. This record is cited below.

CHESTER COUNTY: Kift's Greenhouses, West Chester, June 13, 1925. *Wm. Trimble*. A.

Maine to Alabama; British Columbia and the Pacific Coast and Rocky Mountain States, to Oklahoma and Texas. Introduced from Europe.

4. H. VULGARE L. Common Barley.

Occasionally growing from scattered seed, but not persisting.

26. LOLIUM L.

1. Glume equalling or exceeding the uppermost floret of the spikelet; lemmas awned ..... 2. *L. temulentum*

1. Glume not equalling the uppermost floret.
2. Lemmas usually awnless; spikelets usually with ten or fewer florets ..... 1. *L. perenne*
2. Lemmas usually awned; spikelets with ten or more florets ..... 1A. *L. perenne*, var. *italicum*

1. L. PERENNE L. Perennial Ryegrass.

Fields and waste places, lawns, banks of streams; commonly planted as a lawn grass and occasionally escaping; eastern Pennsylvania, from Lackawanna County southward, mostly on the Piedmont and Coastal Plain, scattered in the western counties.

Generally distributed in the United States; introduced from Europe.

1A. L. PERENNE, var. ITALICUM Parnall. Italian Ryegrass.
L. multiflorum Lam.

Roadbanks, disturbed soil, stream banks; escaped from cultivation; occasional in eastern Pennsylvania from Wayne and Luzerne Counties southward, mostly on the Piedmont; Westmoreland and Allegheny Counties; Jefferson County.

This variety is distinguished from typical *L. perenne* on the basis of its larger size and more vigorous vegetative growth, and by the usually awned lemmas. Statements found in manuals as to the larger size of the lemmas of this variety have not been corroborated by our measurements. At best, var. *italicum* is merely an agronomic variant of the species. Introduced from Europe.

2. L. TEMULENTUM L. Darnel.

Waste ground; rare in extreme southeastern Pennsylvania, on the Coastal Plain and Piedmont in Bucks, Montgomery, Philadelphia and Delaware Counties.

Massachusetts to Georgia, westward to Wisconsin, Kansas and Texas; Arizona; Idaho and the Pacific Coast States. Introduced from Europe.

27. SPHENOPHOLIS Scribn.

1. Lemmas awnless.
   2. At least the second lemma scabrous; panicles slender and delicate; leaf blades and sheaths mostly pubescent ..... 3. *S. nitida*
   2. Lemmas smooth or sometimes minutely papillose, especially on the lower half, but not scabrous.
      3. Second glume very broadly rounded or truncate at the apex, length 2.0-2.5 times the folded width; lower rachilla joint 0.5-0.7 mm. long; panicle usually rather dense ..... 1. *S. obtusata*
      3. Second glume acute, length 3-4 times the folded width; rachilla joint 0.8-1.0 mm. long; panicle rather lax ..... 2. *S. intermedia*
1. Second lemma awned ..... 4. *S. pallens*

1. S. OBTUSATA (Michx.) Scribn.

Thickets and roadsides, serpentine barrens, old fields, swamps. Occasional in southeastern Pennsylvania, on the Piedmont; Wyoming, Montour, Centre, Cumberland and Allegheny Counties. June. Var. *pubescens* (Scribn. & Merr.) Scribn., characterized by having pubescent leaf blades and sheaths, occurs on the serpentine barrens of Delaware and Chester Counties and in Bucks and Luzerne Counties.

Maine to British Columbia, southward to Mexico.

2. S. INTERMEDIA (Rydb.) Rydb.

Sandy thickets, alluvial flats, shores of streams, open woods; common in eastern and southern Pennsylvania and probably throughout the state. Records are lacking from the northwestern counties. Late May—June.

Newfoundland to Florida, westward to British Columbia and Arizona.

3. S. NITIDA (Biehler) Scribn.

Dry rocky oak woods, mixed hardwood forests, road banks; throughout Pennsylvania. Mid-May—early July.

Massachusetts to Florida, westward to Michigan, Missouri and Texas; North Dakota.

4. S. PALLENS (Biehler) Scribn.

An old specimen of this species, labeled only, "Collins—Philadelphia" is in the Herbarium of the Philadelphia Botanical Club. The handwriting on the label is that of Schweinitz. This specimen matches the specimen of this species in the Muhlenberg Herbarium, discussed by Hitchcock in Bartonia 14:34-35 (1932). In the general herbarium of the Academy of Natural Sciences of Philadelphia is a similar specimen, bearing a pencil-written label in Collin's handwriting, bearing the legend "Catawba Island, Ohio. Z. Collins". It seems very probable that both Schweintz and Collins specimens are identical with the Muhlenberg specimen, and that all are from the Ohio locality, not from Pennsylvania, as has been assumed by some.

In its morphology, *S. pallens* is intermediate between *Trisetum pennsylvanicum*, which it greatly resembles, except for the dimorphic glumes of the former, and species of *Sphenopholis*. I am regarding our few specimens which approximate the Muhlenberg specimen of *S. pallens* as hybrids between *Trisetum pennsylvanicum* and species of *Sphenopholis*. These are cited below.

NORTHAMPTON COUNTY: Swale, 2 mi. n. of Moorestown. *R. L. Schaeffer 18387.* A LEHIGH COUNTY: Low or marshy place in alder thicket at Lehigh Gap. *H. W. Pretz 11779.* A.

28. TRISETUM Pers.

1. Panicle dense, spikelike; spikelets disarticulating above the glumes .....1. *T. spicatum*
1. Panicle open, the branches lax; disarticulation below the spikelets, which fall whole with the upper portion of the pedicel attached .....2. *T. pennsylvanicum*

1. T. SPICATUM (L.) Richt.

This boreal species is known only from one locality in Pennsylvania.

LEHIGH COUNTY: Open shale outcrops along L.V.R.R. about 1½ mi. e. by slightly s.e. of Hoffman P. O., July 15, 1917. *H. W. Pretz 8910.* A.; same locality, June 23, 1918. *H. W. Pretz 9390.* A.

Arctic North America, south to Connecticut, Pennsylvania, Michigan, Minnesota; southward in the western mountains to Central and South America; Roan Mt., North Carolina.

2. T. PENNSYLVANICUM (L.) Beauv.

Meadows, swamps, wet woods, spring basins, along creeks; eastern Pennsylvania from Wyoming and Lackawanna Counties southward; Cumberland, Bedford and Crawford Counties. Common on the Piedmont, apparently rather rare in the mountains and lacking from the Coastal Plain in Pennsylvania. May—June. Specimens with strongly dimorphic glumes are probably hybrids with *Sphenopholis* species. These are discussed under *S. pallens*.

Massachusetts to Florida, westward to Louisiana; Ohio; Tennessee.

29. DESCHAMPSIA Beauv.

1. Awns geniculate and well exserted; rachilla joint attached ot the lower floret 1/5 as long as the floret or shorter; basal leaf blades capillary; sheaths minutely scaberulous .....1. *D. flexuosa*
1. Awns straight or slightly curved, scarcely longer than the floret, included or barely

exserted; rachilla joint of the lower floret about ½ as long as the floret; basal leaf blades flat or folded, not capillary; sheaths smooth .....2. *D. cespitosa*

1. D. FLEXUOSA (L.) Trin.

Shale, sandstone or quartzite ledges, rocky woods, old fields. Fairly common in eastern and southern Pennsylvania, in the Coastal Plain, Piedmont, and Ridge and Valley Provinces; rare or neglected by collectors in the Appalachian Plateau area. Late May—July.

Greenland to Alaska, southward to North Carolina, Michigan and Wisconsin; Arkansas and Oklahoma.

2. D. CESPITOSA (L.) Beauv.

Alluvial flats and thickets, sandy shores, sedge marshes, serpentine barrens; fairly common along larger rivers in eastern Pennsylvania from Pike to Bradford Counties and southward, and on serpentine barrens in Delaware and Chester Counties; Allegheny County. Late May—June.

Greenland to Alaska, southward to West Virginia, Illinois, South Dakota and in the mountains to New Mexico, Arizona and California.

30. AVENA L.

1. Lemmas glabrous, awns straight or lacking .....1. *A. sativa*
1. Lemmas pubescent with white or brown ascending hairs, awns strong, geniculate .....2. *A. fatua*

1. A. SATIVA L. Common Oat.

Oats occasionally persist for a year or two after cultivation, or sprouts from scattered seed. Fatuoid variants, resembling wild oats greatly, occur in commercial varieties of oats and may be confused with *A. fatua*.

2. A. FATUA L. Wild Oat.

Waste ground, in a few localities, mostly in eastern Pennsylvania; Erie County.

Newfoundland to Pennsylvania, westward to the Pacific, much more common in the far West.

31. ARRHENATHERUM Beauv.

A. ELATIUS (L.) Mert. & Koch. Tall Oatgrass.

Roadsides, fields and meadows, border of woods; fairly common throughout Pennsylvania. Late May—June, rarely to September.

This species was introduced from Europe as a forage grass and readily escapes from cultivation, in the eastern and northern United States and Canada.

Var. *biaristatum* Petermann, in which both awns are well developed, has been collected in Northampton, Lehigh, Delaware and Allegheny Counties. It resembles species of *Avena* in having the two florets externally similar, but may be separated from the latter genus by its staminate lower floret.

32. HOLCUS L.

1. Sheaths velvety-pubescent; awn of the second floret minute, bent, included within the glumes; plants tufted, not rhizomatous ..... 1. *H. lanatus*

1. Sheaths, except the lower, glabrous; awn of the second floret geniculate and exserted; plants with slender rhizomes ..... *H. mollis**

1. H. LANATUS L.

Roadsides, old fields, meadows, thickets and woods, river shores throughout Pennsylvania. June—August.

Maine to Georgia, westward to Nebraska and Texas, also in the Rocky Mountain and Pacific Coast States. Introduced from Europe; sometimes cultivated.

33. DANTHONIA Lam. & DC.

1. Ligules of lower leaves 0.3-1.0 mm. long (excluding the auricular tufts of long hairs); inflorescences usually contracted, spikelike, the branches strongly ascending.
2. Lemmas 7.5-10.5 mm. long, densely sericeous, at least along the margins, the teeth aristate, 1/3-1/2 the total length of the lemma ..... *D. sericea**

2. Lemmas 2.5-6.0 mm. long, sparsely villous, the teeth 1/5-1/3 the total length of the lemma ..... 1. *D. spicata*

1. Ligules of lower leaves 2-5 mm. long; inflorescence usually open, the branches divaricate; leaves elongate, usually equalling or exceeding the inflorescence..... ..... 2. *D. compressa*

1. D. SPICATA (L.) Beauv. Poverty Oatgrass.

Dry shale roadsides, dry open ground and rocky woods, sandy old fields, wet meadows, serpentine barrens and sterile soil generally; common throughout the state, but mostly lacking from limestone areas. Late May—early September, The great majority of our specimens are June blooming. The species of *Danthonia* bear cleistogamous spikelets in the lower sheaths.

Newfoundland to British Columbia, southward through the United States except the far Southwest.

2. D. COMPRESSA Austin.

Open dry ground, dry rocky woods, shale banks, railroad embankments, moist woods and wet meadows; throughout the state but apparently less common than the preceding species; mostly lacking from limestone areas. Mid-June—July.

Nova Scotia and Quebec to North Carolina and Tennessee.

34. CALAMAGROSTIS Adans.

FERNALD, M. L. 1933—*Calamagrostis epigeios*, var. *georgica* in America. Rhodora **35**:64-75; LOUIS-MARIE, FATHER, O.C. 1944—The Ancylatheran *Calamagrostis of Eastern North America*. Ibid. **46**:285-305; STEBBINS, G. L. 1930—A revision of some North American species of *Calamagrostis*. Ibid. **32**:35-57.

1. Awn geniculate, twisted below, laterally exserted from the glumes, inserted near the base of the lemma; callus hairs scanty, about half as long as the floret ..... 1. *C. porteri*

1. Awn not geniculate nor twisted, included; callus hairs abundant, more than half as long as the floret.

2. Rachilla prolonged behind the palea as a hairy bristle.

3. Awn short, inserted near the tip of the lemma; rachilla naked below, with a prominent apical tuft of hairs which reach about to the apex of the floret; grain pubescent, especially near the apex; panicle dense, spikelike ..... 3. *C. cinnoides*

3. Awn inserted on the lower half of the lemma; rachilla hairy from base to tip; grain glabrous; panicle usually open.

4. Spikelets 2.8 mm. or more long; glumes acute to acuminate, distinctly longer than the floret; panicle mostly open ..... 2. *C. canadensis*

4. Spikelets 2.2-2.8 mm. long; glumes acute, about as long as the floret; panicle contracted ..... 2A. *C. canadensis*, var. *macouniana*

2. Rachilla obsolete, 0.3 mm. or less long, glabrous ..... 4. *C. epigeios*

1. C. PORTERI A. Gray.

Open woods, road banks, cut-over areas, mostly from 1000-2000 ft. elevation; Snyder, Centre, Huntingdon and Bedford Counties. This species was formerly regarded as one of the rarest of American Spermatophytes. Abundant recent collections by Dr. David Berkheimer in Bedford County indicate that it is at least at the present time much more widespread than has been believed. A number of recent specimens are from roadsides, which would seem to indicate that the plant has a preference for disturbed soil. Mid-July—early September.

New York to West Virginia and Virginia (Ohio?).

2. C. CANADENSIS (Michx.) Beauv. Bluejoint.

Marshes, swamps, wet shores, alluvial woods; scattered through the state, probably more common northward. Mid-June—August. This is a highly variable species.

2A. C. CANADENSIS, var. MACOUNIANA (Vasey) Stebbins.

Infrequent; Luzerne, Monroe, Delaware, Fayette, Crawford and Erie Counties.

Calamagrostis canadensis and its variants range from Greenland to Alaska, southward through the United States except Texas, Oklahoma, and eastward through the southeastern states.

3. C. CINNOIDES (Muhl.) Barton.

Rocky or sandy open woods and thickets, alluvial woods, swamps; eastern and southern Pennsylvania, in the Piedmont and Ridge and Valley Provinces, lacking from the higher portions of the Appalachian Plateau; Clarion, Fayette and Westmoreland Counties. Mid-July—early September.

Maine to Georgia and Alabama.

4. C. EPIGEIOS (L.) Roth.

Established at Elkins Park, Montgomery County.
Introduced from the Old World; established in Massachusetts.

35. AMMOPHILA Host.

A. BREVILIGULATA Fernald. Beachgrass.

Sandy beaches along Lake Erie, Presque Isle, Erie County. July. This species is an excellent sand binder, producing strong, widely-spreading rhizomes. It ranges from Newfoundland to North Carolina, along the coast, and in the interior along the St. Lawrence River and the Great Lakes as far inland as Lakes Michigan and Superior.

36. AGROSTIS L.

FERNALD, M. L. 1933—Contrib. Gray Herbarium 101. Recent discoveries in the Newfoundland flora. Rhodora **35**:207-211; PHILIPSON, W. R. 1937—A revision of the British species of the genus Agrostis Linn. Journ. Linnean Society of London (Botany) **51**:73-151.

1. Palea at least ½ as long as the lemma.
   2. Rachilla prolonged behind the palea as a naked bristle; lemmas long-awned ..... A. *spica-venti**
   2. Rachilla not prolonged; lemmas awnless or with a delicate geniculate awn scarcely longer than the glumes.
      3. Panicle open, delicate, the branches naked at the base; ligules on sterile shoots (innovations) 1 mm. or less long, on the culms less than 2 mm. long; leaf blades mostly 1-3 mm. wide; plants erect ..... 3. *A. tenuis*
      3. Panicle open or contracted, at least some of the branches floriferous to the base; ligules of culm blades 3-7 mm. long; leaf blades mostly 2-6 mm. wide; plants erect or decumbent.
         4. Plants rhizomatous; the culms erect; panicle branches spreading, panicle not contracted after flowering ..... 2. *A. alba*
         4. Plants not rhizomatous; culms decumbent, creeping and rooting at the nodes, often forming large mats; panicle narrow, contracted after flowering ..... 1. *A. palustris*

1. Palea less than ¼ as long as the lemma or lacking.
   5. Panicle very diffuse, the lower branches elongate, branching above the middle or toward the tip.
      6. Spikelets 1.4-2.1 mm. long, closely clustered and usually short-pedicellate or subsessile near the tips of the panicle branches; plants blooming from late May to early June ..... 5. *A. hyemalis*
      6. Spikelets 2.0 mm. long or longer; pedicels frequently as long as the more scattered spikelets; plants blooming July-September ..... 6. *A. scabra*
   5. Panicle open, the branches forking near or below the middle.
      7. Anthers minute, globular, 0.2 mm. long; lemmas usually awned with a very thin, flexuous, cobwebby awn as much as five times the length of the lemma; plants annual ..... 4. *A. elliottiana*
      7. Anthers 0.4-0.8 mm. long; spikelets usually green; lemmas usually awnless, rarely with a short, geniculate awn; plants perennial ..... 7. *A. perennans*

7. Anthers (0.8-) 1.0-1.5 mm. long; spikelets usually purple; lemmas usually awned with a straight or geniculate awn; plants perennial ..... *A. canina**

1. A. PALUSTRIS Huds. Creeping Bent.

Wet ground, meadows, shores of ponds and streams; occasional in the northern counties and southward in the mountains to Bedford County; Lehigh, Bucks, Montgomery, Philadelphia and Delaware Counties. Late June—early September.

Introduced from Europe and cultivated as a lawn grass.

2. A. ALBA L. Redtop.

Redtop is commonly cultivated for forage and lawns and escapes very freely; roadsides, waste ground, abandoned fields, meadows, shores of streams, open woods, often on wet ground; common through the state. June—August. Like *A. perennans*, this polymorphous species has shade forms which have delicate, open panicles quite unlike those of plants of open ground. Introduced from the Old World.

3. A. TENUIS Sibth.

Dry soil, open ground, waste places, roadsides; not common; from Bradford and Wayne Counties to Delaware County; Potter, Centre, Huntingdon, Fulton, Cambria and Fayette Counties. The awned f. *aristata* (Parn.) Wieg. has been collected in Monroe, Schuylkill and Wayne Counties.

This species is cultivated for forage and lawns and has escaped from Newfoundland to Virginia and Michigan; British Columbia and the Pacific Coast States. Introduced from Europe.

4. A. ELLIOTTIANA Schult.

This unusual little plant is known from Pennsylvania by the single collection cited below. The awns are so exceedingly fine as to be readily overlooked.

MONTGOMERY COUNTY: Public playground, alt. 140 ft., ½ mi. n.w. of Pottstown, May 25, 1944. *D. Berkheimer 4588*. A., P.

Pennsylvania to Illinois and Kansas and southward; Maine; Massachusetts; Yucatan.

5. A. HYEMALIS (Walt.) B.S.P.

Waste ground, serpentine barrens, boggy ground, on the Piedmont and Coastal Plain, from Bucks and Berks Counties to Lancaster County; Centre and Allegheny Counties. Late May—early June.

Massachusetts to Florida, mostly on the Coastal Plain; westward to Texas and north in the interior to Indiana and Kansas.

6. A. SCABRA Willd.

Roadsides, wet meadows, woods, sometimes in shallow water; mostly in the Ridge and Valley and Appalachian Plateau Provinces; rare on the Coastal Plain and Piedmont; apparently more common northward. Late June—September.

Labrador to Pennsylvania, westward to Alaska, Iowa, New Mexico, Arizona and California.

7. A. PERENNANS (Walt.) Tuck.

Common through the state. Typical *A. perennans* is an erect plant of open ground, dry roadsides, old fields, etc. It has a rather stiff panicle with the spikelets rather appressed along the branches. In moist woods, a slender, lax form occurs, with a very delicate, open panicle, the pedicels very divaricate. Numerous gradations between these two types occur. The woodland form has been designated as var. *aestivalis* Vasey. It appears to be an ecological response to the woodland environment. Awned individuals occur sporadically among the woodland and open ground populations. Mid-July—October.

Quebec to Florida, westward to Minnesota and Texas.

Agrostis altissima (Walt.) Tuck., with spikelets usually somewhat larger than those of *A. perennans*, usually purple and strongly clustered near the tips of the branches, and with harsh, scabrid foliage, has been collected in a *Sphagnum* bog at Willow Grove, and also at Ardsley, both in Montgomery County. This species is primarily a plant of the Coastal Plain pine barrens bogs. Both collections were made around 1900, and the plant has not been collected in Pennsylvania since.

37. CINNA L.

1. Spikelets 4.5-5.9 mm. long; panicle usually rather dense ..... 1. *C. arundinacea*
1. Spikelets 3.0-4.2 mm. long; panicle usually lax ..... 2. *C. latifolia*

1. C. ARUNDINACEA L.

Banks of streams, marshes, low alluvial woods and thickets, ravines; throughout the state. August—October.

Both this and the following species vary considerably in the density of the panicle. The spikelets increase in size until full maturity; measurements should be made upon fully expanded ones, those at the tip of the panicles usually being the most advanced.

Maine to Georgia, westward to South Dakota and Texas.

2. C. LATIFOLIA (Trevir.) Griseb.

Shores of lakes and banks of streams, cool damp woods and ravines, tamarack bogs; mostly in the northern half of the state and south in the mountains to Somerset County; absent from the Coastal Plain and Piedmont, rather widespread in northern Pennsylvania. July—August.

Maine to North Carolina, westward to the Dakotas; Rocky Mountain and Pacific Coast States.

38. ALOPECURUS L.

1. Spikelets 4 mm. or more long.
  2. Panicle ovoid; glumes indurate, yellow and saccate below, abruptly contracted above ..... *A. rendlei**
  2. Panicle cylindrical; glumes not saccate, yellow, or contracted.
    3. Spikelets ovate, narrowed at the apex, 5 mm. or more long; lemmas tapering to an acute apex.

4. Glumes scabrous or short-ciliolate on the keel; summit of the pedicel askew, dilated into a cartilaginous disk; panicles 3-5 mm. in diameter ..... 1. *A. myosuroides*

4. Glumes strongly ciliate on the keel; summit of the pedicel not strongly dilated; panicles 7-10 mm. in diameter ..... 2. *A. pratensis*

3. Spikelets truncate, wedge-shaped, broadest at the apex, about 4 mm. long; lemmas truncate ..... *A. creticus**

1. Spikelets 2-3 mm. long.

5. Awn included or barely exserted, straight ..... 3. *A. aequalis*

5. Awn exserted about 2 mm., usually curved.

6. Anthers 1-2 mm. long; culms weak and spreading, rooting at the nodes..... ..... 4. *A. geniculatus*

6. Anthers 0.3-0.6 mm. long; culms mostly ascending, not often rooting at the nodes ..... 5. *A. carolinianus*

1. A. MYOSUROIDES Huds.

Fields and waste places; ballast ground at Philadelphia; Brookfield, Chester County; Pleasant Grove, Lancaster County.

Maine to North Carolina; Kansas; Texas; Pacific Northwest. Introduced from the Old World.

2. A. PRATENSIS L. Meadow Foxtail.

Meadows and waste places; Wayne, Berks, Bucks and Philadelphia Counties; rare. June.

Maine to West Virginia, westward to Minnesota and Missouri; Georgia; Oregon and Idaho. Introduced from the Old World.

3. A. AEQUALIS Sobol.

Swamps, ditches, wet shores and meadows; Luzerne, Huntingdon, Allegheny and Mercer Counties, and around Philadelphia, from Bucks County to Delaware County. This species is apparently rare in Pennsylvania, except around Philadelphia, where it occasionally becomes a weed in gardens and on disturbed soil. Late May—June.

Boreal America, southward to New Jersey, Illinois, Missouri, New Mexico and California; Eurasia.

4. A. GENICULATUS L.

This species was once collected as a ballast waif at Philadelphia, where it probably no longer exists, but it is to be sought as a native in northern Pennsylvania.

Boreal North America, southward to Virginia and Michigan in the East and Arizona and California in the western mountains; Eurasia.

5. A. CAROLINIANUS Walt.

Low meadows and marshes; Lackawanna County, Philadelphia and Delaware Counties; apparently rare in Pennsylvania. May—September.

New Jersey to Florida, westward to British Columbia and the Pacific Coast States.

39. PHLEUM L.

1. Glumes oblong, truncate, the midrib exserted as an awn, the keel strongly ciliate ..... 1. *P. pratense*

1. Glumes lanceolate to ovate, tapering to an acute apex, not ciliate ..... *P. subulatum**

1. P. PRATENSE L. Timothy.

Fields and meadows, roadsides and waste ground; throughout the state; common. June and July, rarely later.

Timothy is important forage and hay crop; it escapes from cultivation and often becomes naturalized throughout the United States. Introduced from Europe.

40. MUHLENBERGIA Schreb.

FERNALD, M. L. 1943—Five common rhizomatous species of *Muhlenbergia*. Contrib. Gray Herbarium 148. Rhodora **45**:221-39.

1. Plants with prominent creeping, scaly rhizomes.
   2. Glumes reduced, the first about one fourth as long as the floret, the second slightly longer ..... 9. *M. curtisetosa*
   2. Glumes at least half as long as the floret.
      3. Glumes shorter than the floret, broad below, abruptly tapering to an acuminate apex.
         4. Spikelets 1.7-2.5 mm. long, awnless; larger leaf blades mostly 3-6 mm. wide ..... 2. *M. sobolifera*
         4. Spikelets, excluding the awns, 3.0-4.5 mm. long; lemmas long-awned; larger leaf blades 5-13 mm. wide ..... 3. *M. tenuiflora*
      3. Glumes tapering from near the base to an acuminate or awned apex, shorter or longer than the floret.
         5. Glumes about as long as the floret or shorter, the second 3.5 mm. or less long.
            6. Culms freely branching, with numerous axillary, often partly included panicles; internodes glabrous and shining ..... 5. *M. frondosa*
            6. Culms sparingly branching, the branches mostly elongated and bearing exserted terminal panicles; internodes dull, harsh-puberulent, especially near their summits.
               7. Panicle branches spikelet-bearing mostly to their bases with densely-clustered sessile or subsessile spikelets; lemmas usually awnless..... 7. *M. mexicana*
               7. Panicle branches very slender, appressed, the longer ones naked at the base; some of the spikelets on pedicels as long as the glumes or longer; lemmas usually long-awned ..... 6. *M. sylvatica*
         5. Glumes awned, much exceeding the floret, 4.5 mm. or more long; panicle dense, spikelike, usually lobed ..... 4. *M. glomerata*

1. Plants tufted or sprawling and rooting at the lower nodes, lacking rhizomes.
   8. Panicle diffuse, the spikelets on elongated capillary pedicels; glumes about half as long as the spikelets.
      9. Lemmas awnless; spikelets about 1.5 mm. long ..... 1. *M. uniflora*

9. Lemmas bearing awns 5-15 mm. long; spikelets, excluding the awns, 4.0-5.5 mm. long ..... 10. *M. capillaris*

8. Panicle slender, the branches appressed; spikelets short-pedicellate; glumes minute, 1/10 as long as the floret or shorter; lemmas awned ..... 8. *M. schreberi*

1. M. UNIFLORA (Muhl.) Fernald.

Rare; marshes of Wyoming, Sullivan and Luzerne Counties; Haverford, Delaware County. August—September.

Newfoundland to New York, Pennsylvania and New Jersey; Upper Michigan and Wisconsin.

2. M. SOBOLIFERA (Muhl.) Trin.

Dry rocky wooded slopes; occasional in the southern half of the state and in the northeastern Counties. End of July—early October.

New Hampshire to Virginia, westward to Iowa, Kansas and Texas.

3. M. TENUIFLORA (Willd.) B.S.P.

Rich or rocky wooded slopes, mostly along streams; apparently rather rare; southern half of Pennsylvania; Luzerne and Crawford Counties. Late July—September.

Ontario to Virginia, westward to Iowa and Arkansas.

4. M. GLOMERATA (Willd.) Trin.

Sandy thickets, rocky hillsides, marshy ground; probably through Pennsylvania, but most of our records are from the eastern fourth of the state, with a few scattered stations through the remainder. Mid-July—October. This species is united in recent manuals with *M. racemosa* (Michx.) B.S.P., which is more western in its distribution, and has anthers 0.5-0.8 mm. long and a linear-cylindric grain. *M. glomerata* is distinguished by its large anthers, 1.0-1.5 mm. long, and narrowly ellipsoid grain. Small northern forms with few leaves have been differentiated as var. *cinnoides* (Link) Hermann.

Newfoundland to Pennsylvania (and southward in the mountains to North Carolina); westward to Alberta, Indiana, Wisconsin, Minnesota, Wyoming, Oregon and Nevada.

5. M. FRONDOSA (Poir.) Fernald.

M. mexicana of current manuals

Stream banks, alluvial thickets and meadows, roadsides, old fields and dry woods; common through the state. Late August—early October. Typical *M. frondosa* has awnless lemmas. The awned f. *commutata* (Scribn.) Fernald, is infrequent.

New Brunswick to Virginia and Georgia, westward to North Dakota and Texas.

6. M. SYLVATICA Torr.

Including var. *robusta* Fernald

Banks of streams, ravines, rocky wooded hillsides, roadsides, meadows and

alluvial thickets; occasional through the state; absent from the Coastal Plain. August—September.

Quebec to North Carolina, westward to South Dakota and Texas; Arizona.

7. M. MEXICANA (L.) Trin.

M. foliosa of current manuals

Rocky shores and woods, swamps and swales, serpentine barrens; occasional on the Piedmont and Coastal Plain in southeastern Pennsylvania, with a few scattered stations through the remainder of the state. F. *ambigua* (Torr.) Fernald, with awned lemmas, has been collected in Schuylkill County.

Quebec and Maine to North Carolina, westward to Washington, California and Arizona.

8. M. SCHREBERI Gmel. Nimble Will.

Woods and thickets, waste ground, roadsides and streets, old fields and meadows; common through the state. Mid-August—October; rarely blooming in June or July.

New Hampshire to Florida, westward to Wisconsin, Nebraska and Texas.

9. M. CURTISETOSA (Scribn.) Bush.

This unusual plant has the reduced glumes of *M. schreberi*, but the size, habit, and rhizomes of other species, notably *M. frondosa*. It has been previously known only from a few localities in Illinois and Missouri. The disjunct range and morphological intermediacy of this plant make it probable that it is a hybrid. The two stations known for *M. curtisetosa* in Pennsylvania are cited below.

NORTHAMPTON COUNTY: Bethlehem, August 10, 1894, *G. W. Caffrey*. S. DELAWARE COUNTY: Open field, 1 mi. s.w. of Darby P. R.R. Station, September 23, 1938. *W. M. Thompson, Jr. 502*. P., U.S. (This area has now been devastated by building operations.)

10. M. CAPILLARIS (Lam.) Trin.

Rare, known in Pennsylvania only from the following collection in Lancaster County.

LANCASTER COUNTY: Safe Harbor, October 10, 1864. *T. S. Porter*. P., S., A.

Massachusetts to Florida and Texas, northward in the interior to Kansas, Illinois and Indiana.

41. SPOROBOLUS R. Br.

1. Lemmas pubescent.
   2. Terminal panicles exserted, 3-10 cm. long; plants perennial, mostly 50-90 cm. tall; culms with hard bases which at flowering time bear numerous short, scaly buds of the next year's culms ..... 4. *S. clandestinus*
   2. Terminal panicles mostly included, or if exserted, then slender, few-flowered, 1-3 cm. long; plants shallow-rooted annuals, tufted, lacking scaly buds at flowering time ..... 1. *S. vaginaeflorus*

1. Lemmas glabrous.
   3. Glumes subequal, about as long as the floret ..... 2. *S. neglectus*

3. Glumes markedly unequal or much shorter than the floret.
   4. Spikelets 4-7 mm. long.
      5. Panicle open, exserted; second glume exceeding the floret; caryopsis at maturity spherical, bursting from the lemma and palea .....5. *heterolepis*
      5. Panicle spikelike, usually partly or wholly included in the upper sheath; second glume shorter than the floret; caryopsis not spherical, not bursting from the lemma and palea .....3. *S. asper*
   4. Spikelets 1.4-3.0 mm. long.
      6. Glumes markedly unequal, the second about as long as the floret.
         7. Panicle partly or wholly included in the upper sheath, the lower branches mostly single or paired; spikelets 2-3 mm. long; sheaths bearing prominent tufts of white hairs on the throat and collar .....6. *S. cryptandrus*
         7. Panicle exserted at maturity, pyramidal, the lower branches whorled; spikelets 1.4-1.8 mm. long; sheaths slightly ciliate at the throat ..... *S. pulvinatus**
      6. Glumes subequal, about half as long as the floret; panicle spikelike ..... *S. poiretii**

1. S. VAGINAEFLORUS (Torr.) Wood.

Dry or sterile soil, railroad embankments, quarries and gravel pits, roadsides, waste ground, serpentine barrens. End of August—October. Most of our records are from the Coastal Plain and Piedmont, but we have seen specimens from scattered localities through the state. Probably this grass is much more common than our records indicate but is overlooked because of its small size, late blooming, and mostly concealed panicles. A few specimens from northern counties have the palea beak-like and prolonged a half millimeter or more beyond the tip of the lemma. These may be referred to var. *inaequalis* Fernald. There is a good deal of variation in the length of the palea among our specimens.

Maine to Georgia, westward to Minnesota, Texas, New Mexico and Arizona.

2. S. NEGLECTUS Nash.

Known in Pennsylvania only by the following collections:

LEHIGH COUNTY: ¾ mi. s.e. by e. of Centre Square, Allentown, August 31, 1915. *H. W. Pretz 7854*. A. ALLEGHENY COUNTY: Pittsburgh, Forbes St. near bridge, September, 1895. *B. H. Patterson*. C., P.

Quebec to Maryland, westward to North Dakota and Texas; Arizona; Washington.

3. S. ASPER (Michx.) Kunth.

Dry banks and railroad embankments; valleys of the Delaware and Susquehanna Rivers and their larger tributaries; Lackawanna, Luzerne, and Monroe Counties and southward; Lycoming County. August—early September.

Quebec to Virginia, Tennessee and Mississippi, westward to North Dakota, Utah and New Mexico; Washington.

4. S. CLANDESTINUS (Biehler) Hitch.

Known in Pennsylvania only by the following collection.

DAUPHIN COUNTY: Harrisburg, October 1882. *T. C. Porter.* A.

5. S. HETEROLEPIS A. Gray.

This is a prairie species, known in Pennsylvania only from the Nottingham and Lee's Bridge serpentine barrens of Chester County.

Quebec to Connecticut and Pennsylvania, westward to Saskachewan and Illinois, Arkansas and Texas and through the prairie and plains country.

6. S. CRYPTANDRUS (Torr.) Gray. Sand Dropseed.

Waste ground; Luzerne, Lehigh and Philadelphia Counties; sand beaches along Lake Erie, Erie County.

Maine to Alberta, southward through the United States to Mexico, lacking from the southeastern states.

42. HELEOCHLOA Host.

1. Panicles ovoid-cylindric, 5-8 mm. thick, 1-4 cm. long, the base included in the inflated upper sheath ..... 1. *H. schoenoides*

1. Panicles slender-cylindric, 4-5 mm. thick, 4-6 cm. long, exserted or the base barely included in the tight sheath of the uppermost leaf ..... *H. alopecuroides**

1. H. SCHOENOIDES (L.) Host.

Waste ground and along streets; Bucks, Montgomery, Philadelphia and Delaware Counties. Although most of our records for this species are from the 1870s, it has been collected in Philadelphia as recently as 1937, and may recur there.

Massachusetts to Delaware, westward to Wisconsin and Illinois. Introduced from Europe.

43. BRACHYELYTRUM Beauv.

BABEL, WM. K. 1943—The variations of *Brachyelytrum erectum.* Rhodora **45**:260-62.

1. Lemmas bearing lines of short, strong hispid hairs along the nerves, the internerves glabrous ..... 1. *B. erectum*

1. Lemmas scaberulous over the surface or nearly glabrous ..... 1A. *B. erectum,* var. *septentrionale*

1. B. ERECTUM (Schreb.) Beauv.

Rocky wooded hillsides; known from southeastern Pennsylvania, from Northampton County to Cambria County and southward, also in Wayne, Lackawanna, Tioga, Clarion, Fayette and Crawford Counties; apparently most common on the Piedmont. June—July, rarely later.

Massachusetts to Georgia, westward to Wisconsin and Louisiana.

1A. B. ERECTUM, var. SEPTENTRIONALE Babel.

Rich, mixed hardwood forests, alluvial woods, swamps and moist thickets;

from Northampton and Berks Counties to Venango County and northward, southward on the Appalachian Plateau to Fayette and Somerset Counties. This variety is more common in Pennsylvania than typical *B. erectum*, and distinctly more boreal. Its habitat preferences are different, and it is much more gregarious, growing in large, almost pure stands in moist thickets in the northern counties. One specimen is known from Chester County, well south of the main body of the range in southeastern Pennsylvania. Here the plant grew in a swamp with numbers of other species of boreal affinities. June—July.

Newfoundland to Connecticut and New Jersey and westward to Wisconsin, southward in the mountains to Virginia (Giles County); Japan.

44. MILIUM L.

M. EFFUSUM L.

Rich, cool woods, in the northern half of the state, southward on the Appalachian Plateau to Somerset County; apparently rather infrequent. Late May—July.

Quebec to West Virginia, westward to Minnesota and Illinois; Eurasia.

45. ORYZOPSIS Michx.

1. Spikelets 6-9 mm. long; leaves flat.
   2. Lower leaf blades on the culms reduced, much shorter and narrower than the upper ones; mature fruit black ..... 3. *O. racemosa*
   2. Upper leaf blades on the culms much reduced, the foliage mostly basal; mature fruit stramineous ..... 2. *O. asperifolia*
1. Spikelets less than 5 mm. long.
   3. Lemma strongly pubescent; awn very short or lacking; glumes broadly rounded at the apex; leaf blades mostly involute ..... 1. *O. pungens*
   3. Lemma glabrous; awn about as long as the lemma; glumes acuminate ..... *O. miliacea**

1. O. PUNGENS (Torr.) Hitch.

Dry sandy thickets, pine-oak and *Myrica* barren, rock fissures; in the mountains of Lackawanna, Pike, Luzerne and Monroe Counties; rare and local. May.

Labrador to Pennsylvania, westward to British Columbia and Colorado.

2. O. ASPERIFOLIA Michx.

Dry sandy or rocky woods, from northern Pennsylvania, down the mountains to Bedford and Somerset Counties; absent from the Coastal Plain and Piedmont. May and early June.

Boreal America, southward to Pennsylvania, Indiana, Minnesota, South Dakota, New Mexico, and Idaho.

3. O. RACEMOSA (J. E. Smith) Ricker.

Open rocky woods; Wayne County to Cameron County, southward to Philadelphia and Somerset Counties. Very few collections are known from the western half of the state. Late June—August.

Quebec to Delaware, westward to South Dakota.

46. STIPA L.

1. Glumes 1.0-1.3 cm. long, thin and translucent, usually purplish at the base ..... 1. *S. avenacea*

1. Glumes 2.5-4. cm. long, firm and greenish ..... 2. *S. spartea*

1. S. AVENACEA L.

Dry thin rocky woods, sandy open places, railroad embankments; of infrequent occurrence in Pennsylvania, on the Coastal Plain and Piedmont from Bucks and Berks Counties to Philadelphia and Lancaster Counties; Cumberland and Mercer Counties. May and early June.

Massachusetts to Florida to Michigan and Texas, chiefly on the Coastal Plain.

2. S. SPARTEA Trin. Porcupine Grass.

This is a prairie species, known here only as a waif and collected only once. LACKAWANNA COUNTY: Roadside, Dalton, July 9, 1927. *E. M. Gress.* H., A.

Ontario to Pennsylvania, westward to British Columbia and New Mexico.

47. ARISTIDA L.

FERNALD, M. L. 1933—Some forms of grasses. Rhodora **35**:316-19; HENRARD, J. TH. 1926-28—A critical revision of the genus *Aristida*. Mededeelingen Van's Rijks Herbarium Leiden, 54, 54A, 54B, pp. 1-747; HENRARD, J. TH. 1929-33—A monograph of the genus *Aristida*. Ibid. 58 Vols. I & II; HITCHCOCK, A. S. 1924—The North American species of *Aristida*. Contrib. U.S. Nat. Herbarium **22**: pt. 7; SHINNERS, L. H. 1940—*Aristida basiramea* and its relatives. American Midland Naturalist **23**:633-34.

1. Lateral awns half as long as the central awn or shorter.

2. Central awn spirally coiled at the base.

3. Glumes markedly unequal, the second nearly reaching the middle of the lateral awns, the first ½-¾ as long as the second ..... 2. *A. basiramea*, var. *curtissii*

3. Glumes subequal, both surpassing the point of insertion of the awns of the lemma ..... 3. *dichotoma*

2. Central awn reflexed, not spirally coiled, usually 8-19 mm. long.

4. Lateral awns 1/5-1/3 as long as the central awn ..... 4. *A. longispica*

4. Lateral awns 1/3-1/2 as long as the central awn ..... 4A. *A. longispica*, var. *geniculata*

1. Lateral awns about as long as the central awn.

5. Second glume 2-3 cm. long; awns usually 4-6 cm. long; plants annual ..... 3. *A. oligantha*

5. Second glume 9-14 mm. long; awns usually 1.5-2.5 cm. long; plants perennial ..... 5. *A. purpurascens*

1. A. DICHOTOMA Michx.

Dry sterile sandy or rocky open ground, open woods, railroad embankments and disturbed soil generally; rather common in the southern half of the state and also in Lackawanna County. Mid-August—early October. Forma *major* Shinners, with somewhat larger spikelets, and the straight portion of

the central awn 6 mm. or more long, has been collected at York Furnace, York County.

Maine to Florida, westward to Kansas and Texas.

2. A. BASIRAMEA Engelm., var. CURTISSII (Gray) Shinners.

This variety is mostly midwestern; the following occurrences are probably introductions.

LANCASTER COUNTY: Martic Hills. 1886. *Jas. Galen.* C. BEDFORD COUNTY: Roadside, alt. 840 ft., 2⅜ mi. s. of Hyndman, September 1, 1946. *D. Berkheimer 7959.* P.

Wisconsin and Illinois to Wyoming and Oklahoma; Pennsylvania to Virginia and West Virginia; Florida. The eastern occurrences are probably waifs.

3. A. OLIGANTHA Michx.

Occasional; dry sandy fields, gravel pits, railroad embankments, waste ground, serpentine barrens; mostly on the Piedmont and Coastal Plain, from Berks to Bucks and Chester Counties; Lackawanna County; Adams County; Allegheny County. Late August—October.

Massachusetts to Florida, westward to South Dakota and Texas; Oregon to Arizona.

4. A. LONGISPICA Poir.

Occasional on the Piedmont, from Lehigh County to Chester and Delaware Counties, mostly on serpentine barrens. August—September.

Connecticut and New Jersey to Illinois and Kansas, southward to the Gulf of Mexico.

4A. A. LONGISPICA, var. GENICULATA (Raf.) Fernald.

Coastal Plain and Piedmont, from Northampton County to Chester County; more widespread than typical *A. longispica* in the state.

New England to Ohio and Indiana and southward.

5. A. PURPURASCENS Poir.

Dry soil, mostly on serpentine barrens; apparently rather rare; southeastern Pennsylvania, from Delaware County to York County; Luzerne, Northampton and Franklin Counties. August—September.

Massachusetts to Florida, westward to Wisconsin, Kansas and Texas.

48. ELEUSINE Gaertn.

E. INDICA (L.) Gaertn. Goosegrass.

A common annual weed of streets, waste places, gardens and disturbed soil generally. Available records would seem to indicate that this species is more common in southern Pennsylvania than in the northern portion of the state. June—October.

Pantropical; introduced in the eastern United States from Massachusetts to South Dakota and southward; Oregon and California.

49. DACTYLOCTENIUM Willd.

D. AEGYPTIUM (L.) Richt.

Waste places around Philadelphia; Springfield, Delaware County. This introduced grass from the tropics of the Old World was collected in Philadelphia several times during the 1850s and 60s, and again in 1937 and 1938. It somewhat resembles goosegrass. September—October.

Coastal Plain, North Carolina to Florida, westward to Texas; Arizona; Illinois; New Jersey to Maine.

50. CYNODON Rich.

C. DACTYLON (L.) Pers. Bermuda Grass.

Waste ground, mostly confined to southeastern Pennsylvania, on the Coastal Plain and Piedmont, from Northampton County and Berks County to Bucks and Delaware Counties; Carlisle. Uncommon. July—October.

Bermuda Grass is an important stoloniferous and rhizomatous perennial, now of pantropical occurrence, but introduced in this hemisphere. It is cultivated in the South as a forage and lawn grass.

Massachusetts to Florida, westward to Iowa, Texas, thence to California and Oregon; of sporadic occurrence in the North.

51. BECKMANNIA Host.

B. SYZIGACHNE (Steud.) Fernald. Sloughgrass.

Represented from Pennsylvania only by a single specimen, cited below, which is probably a waif from the West.

PHILADELPHIA COUNTY: Natural alluvial meadows along the Delaware River, Broad and Pattison Sts., Philadelphia, June 10, 1921. *Bayard Long 24450*. A., P.

52. SPARTINA Schreb.

S. PECTINATA Link.

Occasional on wet sandy shores and alluvial flats, mostly along the larger rivers through Pennsylvania. Late July—September.

Quebec to Washington and southward; absent from the far Southwest and from the southeastern states.

53. GYMNOPOGON Beauv.

G. AMBIGUUS (Michx.) B.S.P.

Known in Pennsylvania only by several collections from a single locality in southern Lancaster County.

LANCASTER COUNTY: Hillside, Geiger's Quarries, 1½ mi. s. of Wrightsdale, October 17, 1937. *Wm. H. Auxer*. P.; 1¼ mi. s. of Wrightsdale, October 17, 1937. *Wm. H. Auxer*. P.; 1¼ mi. s.e. of Wrightsdale, barrens (Geiger's Quarry), August 26, 1939. *Louise F. A. Tanger 3572*. P., A.

Pennsylvania to Florida and Texas, mostly on the Coastal Plain; northward in the interior to Kansas and Tennessee.

54. CHLORIS Swartz.

1. Lemmas whitish or stramineous, strongly ciliate near the apex, the awn at least as long as the body; spikes feathery ..... 1. *C. virgata*

1. Lemmas brown, not strongly ciliate, the awn minute; spikes not feathery ..... *C. petraea**

1. C. VIRGATA Swartz.

Adventive from the West, known here only by the following specimen.

PHILADELPHIA COUNTY: Waste ground, fills and rubbish heaps along Hedley St., s. of Bridesburg, October 11, 1942. *Bayard Long 58738*. A.

Nebraska to Texas, westward to California; adventive farther east.

55. BOUTELOUA Lag.

B. CURTIPENDULA (Michx.) Torr. Side-oats Grama.

Dry rock ledges and open hillsides, especially on serpentine and limestone; scattered in the Piedmont and Ridge and Valley Provinces, not known from the Appalachian Plateau except by one specimen from Venango County. August—September.

Maine to West Virginia and Alabama, westward to Montana and California. This is one of the widest ranging of the native American grasses. It is an important forage species in the West.

56. HIEROCHLOE (Gmel.) R. Br.

H. ODORATA (L.) Beauv. Holy Grass.

Rare; moist ground; Wayne, Allegheny and Lawrence Counties. This species is to be sought in the mountains in the northern portion of the state. May—June.

Labrador to Alaska, southward to New Jersey and west to Oregon, south in the Rocky Mountains to Arizona and New Mexico.

57. ANTHOXANTHUM L.

1. Culms unbranched; plants perennial; awns of sterile lemmas scarcely exserted from the glumes; fertile floret about ¾ as long as the sterile ones .... 1. *A. odoratum*

1. Culms branched from lower nodes; plants annual; awns of sterile lemmas exserted at least 2 mm. from the glumes; fertile floret about half as long as the sterile ones ..... 2. *A. aristatum*

1. A. ODORATUM L. Sweet Vernal Grass.

Old fields, meadows, open ground, roadside banks and ditches, open woods; widespread and common through the state. Mid-April—early July. The plants possess the fragrance of coumarin, which persists after drying. Individuals growing in shade may produce very slender, open, few-flowered inflorescences.

Greenland and Newfoundland to Georgia, westward to Michigan and Louisiana; Pacific Coast States. Introduced from the Old World.

2. A. ARISTATUM Boiss.

Known from Bethlehem, where it was apparently introduced with lawn grass

seed around 1900, and from Jeffrey Farm, Forest County, in 1920. Introduced from Europe.

58. PHALARIS L.

1. Spikelets all alike and fertile; glumes mostly persisting on the panicle, the florets falling.

2. Plants tufted, annual; inflorescence short, ovoid, dense, without evident branches; glumes strongly winged, whitish, with prominent longitudinal green stripes..... 1. *P. canariensis*

2. Plants rhizomatous, perennial; inflorescence cylindrical, lobed, the branches usually evident; glumes scarcely winged, whitish or violaceous, with obscure green longitudinal stripes ..... 2. *P. arundinacea*

1. Spikelets in groups of 6 or 7, one fertile and the others sterile; the groups falling as units ..... *P. paradoxa**

1. P. CANARIENSIS L. Canary Grass.

Waste heaps around cities; sprouting from the scattered seed, which is the "canary seed" of commerce; probably never persisting. July—August. Introduced from Europe.

2. P. ARUNDINACEA L.

Swamps, marshes, wet shores and thickets, roadside ditches; widely distributed in Pennsylvania. June—early July. The spikelets often become infested with ergot. Var. *picta* L., in which the leaf blades are longitudinally banded with white, is rarely cultivated for ornament and may escape or persist after cultivation.

New Brunswick to North Carolina, westward to Alaska and northern California.

59. LEERSIA Swartz.

1. Spikelets 4.2-5. mm. long; 1.3-1.7 mm. wide; sheaths usually strongly retrorsely scabrous; rhizomes slender, the elongate internodes exposed ..... 1. *L. oryzoides*

1. Spikelets 2.9-3.9 mm. long, 1.0-1.5 mm. wide; sheaths smooth to slightly scaberulous; rhizomes thick, the short internodes densely covered with imbricated scales ..... 2. *L. virginica*

1. L. ORYZOIDES (L.) Swartz.

Wet ground, mud flats, ditches, shores, bogs and swamps; common throughout the state. Late July—September.

Throughout the United States.

2. L. VIRGINICA Willd.

Ditches, mud flats, damp woods and thickets; common through the state. Mid-July—September.

Quebec to Florida, westward to South Dakota and Texas.

60. ZIZANIA L.

FASSETT, N. C. 1924—A study of the genus *Zizania*. Rhodora **26**:153-60.

1. Pistillate lemmas dull, thin and papery, more or less scaberulous over the entire surface; leaves mostly 1-5 cm. broad ..... 1. *Z. aquatica*

1. Pistillate lemmas shining, firm and leathery, glabrous except along the margins and on the awn and at its base; leaves mostly 1 cm. or less broad ..... 1A. *Z. aquatica*, var. *angustifolia*

1. Z. AQUATICA L. Wild Rice.

Wet marshes and shallow water; apparently confined to the lower Delaware Valley, on the Coastal Plain, and the lower Susquehanna Valley, in York County. Late summer.

Quebec and Maine to Florida, westward to North Dakota, Nebraska and Louisiana; Idaho.

1A. Z. AQUATICA, var. ANGUSTIFOLIA Hitch.

Presque Isle, Erie County.

Quebec and New Brunswick to Pennsylvania, westward to Nebraska.

61. DIGITARIA Heister.

1. Rachis of the spikes broadly winged, the thin wing at least as wide as the midrib.
2. Fruit brown-black at maturity; second glume nearly as long as the spikelet, covering the fruit except at the tip; sheaths glabrous or nearly so ..... 2. *D. ischaemum*

2. Fruit pallid or leaden-gray at maturity; second glume about half as long as the spikelet, narrow, exposing the fruit nearly to the base; sheaths more or less hispid.

3. Pedicels of the spikelets acutely triangular, scabrous on the angles.
4. Spikelets more or less appressed pubescent ..... 1. *D. sanguinalis*

4. Spikelets strongly ciliate, the hairs of the lateral internerves of the sterile lemma spreading, up to 2 mm. long ..... 1A. *D. sanguinalis*, var. *ciliaris*

3. Pedicels of the spikelets terete and smooth ..... *D. serotina**

1. Rachis of the spikes wingless, triangular in cross section ..... 3. *D. filiformis*

1. D. SANGUINALIS (L.) Scop. Crabgrass.

An aggressive and pernicious weed of disturbed soil, roadsides, waste ground, fields and gardens, often invading lawns; probably common throughout the state. July—October

Throughout the United States except at high altitudes; introduced from Europe.

1A. D. SANGUINALIS, var. CILIARIS (Retz.) Parl., Fl. Ital. 1:126. (1848).

This variety has been found near Fleetwood, Berks County. This is apparently the first record of the variety for the United States. Occasional plants of *D. sanguinalis* have somewhat spreading hairs between the lateral internerves of the spikelets, and approach the variety.

BERKS COUNTY: Fleetwood, weed along railroad, September 30, 1931. *Hans Wilkens 1267*. P., A.; same place, October 25, 1936. *Wilkens 5088*. P.; same place, August 15, 1937. *Wilkens 5318-b*. C.

2. D. ISCHAEMUM (Schreb.) Muhl. Smooth Crabgrass.

This grass is similar to *D. sanguinalis* and is found in the same types of habitats, but is usually smaller and more delicate; common through the state. August—October.

Maine to North Carolina, westward to the Pacific Coast States; introduced from the Old World.

3. D. FILIFORMIS (L.) Koel.

Paths, road banks, serpentine barrens; southeastern Pennsylvania, from Northampton County to Dauphin County and southward; Bedford County. August—October.

New Hampshire to Florida, westward to Michigan, Iowa and Texas.

62. LEPTOLOMA Chase.

L. COGNATUM (Schult.) Chase.

Adventive in southeastern Pennsylvania; probably introduced from the sandy lands of the Coastal Plain in New Jersey. This species is known here only by the following two collections.

BERKS COUNTY: 1 mi. slightly n.e. of Plowville, October 1, 1944. *W. C. Brumbach 3841*. A. PHILADELPHIA COUNTY: About old sand pits near mouth of the Pennypack Creek, east of State Road and Ashburner St., July 12, 1942. *Bayard Long 58435*. A.

New Hampshire to Florida, westward to Minnesota, Nebraska, Texas, New Mexico and Arizona; mostly on the Coastal Plain in the Northeast.

63. PASPALUM L.

CHASE, AGNES 1929—The North American species of *Paspalum*. Contrib. U. S. Nat. Herbarium **28**, part 1; FERNALD, M. L. 1934—Some transfers in *Digitaria* and *Paspalum*. Rhodora **36**:19-22.

1. Racemes one to several, not conjugate; plants tufted, not stoloniferous.
   2. Spikelets less than 3.5 mm. long; plants of small to moderate stature, usually less than 1 meter tall.
      3. Leaf blades covered with fine uniform puberulence, long hairs sometimes interspersed ..... 3. *P. psammophilum*
      3. Leaf blades loosely pilose to glabrous, not puberulent.
         4. Inflorescences terminal and axillary, the latter often concealed in the sheaths; spikelets 2.4 mm. or less long.
            5. Spikelets 1.5-1.8 mm. long, minutely pubescent or glabrous ..... 2. *P. setaceum*
            5. Spikelets 2.0-2.4 mm. long, glabrous ....4. *P. ciliatifolium*, var. *muhlenbergii*
         4. Inflorescences terminal, none axillary; spikelets 2.8-3.2 mm. long.
            5. Spikelets obovate, mostly paired, the racemes hence apparently 4-rowed; racemes mostly more than 5, their winged rachises 1.5-2.5 mm. wide; culms decumbent and rooting at the nodes ....1. *P. pubiflorum*, var. *glabrum*
            5. Spikelets broadly elliptical to nearly circular, solitary, the racemes 2-rowed; racemes usually 2-4, their rachises 0.8-1.1 (-1.4) mm. wide; culms erect or ascending, not rooting at the nodes ..... 5. *P. laeve*

2. Spikelets 3.9-4.5 mm. long; plants tall and robust, usually 1-2 m. tall ..... 6. *P. floridanum*, var. *glabratum*

1. Racemes, two, conjugate at the apex of the peduncle; stoloniferous plants of wet places ..... *P. distichum**

1. P. PUBIFLORUM Rupr., var. GLABRUM Vasey.

This species has been found only once in Pennsylvania, at Chester, where it was apparently a waif and probably has not persisted. The specimen is cited below.

DELAWARE COUNTY: Grounds of the American Dyewood Co., Chester, September 20, 1935. *Eva Frank*. P., U.S.

Pennsylvania; North Carolina and Indiana to Florida, Kansas and Texas.

2. P. SETACEUM Michx.

Open dry ground, moist shores; rare; Lehigh, Berks and Bucks Counties. July—September.

New York to Florida and Texas, mostly on the Coastal Plain; Ohio to Tennessee.

3. P. PSAMMOPHILUM Nash.

Dry sandy soil; rare; Bucks, Montgomery and Philadelphia Counties. July—August.

Coastal Plain, Massachusetts to New Jersey and Pennsylvania.

4. P.CILIATIFOLIUM Michx., var. MUHLENBERGII (Nash) Fernald.
P. pubescens Muhl.

Abandoned fields, meadows and waste ground, sometimes on serpentine. This is by far our most common and widespread species of this genus. It is common on the Coastal Plain and Piedmont from Northampton County southward; Lackawanna, Luzerne, Schuylkill, Bedford, Beaver and Washington Counties. July—September.

New Hampshire to Florida, westward to Michigan and Texas.

5. P. LAEVE Michx.

Abandoned fields, meadows, marshes, serpentine barrens, waste ground; fairly common on the Piedmont and Coastal Plain from Northampton County to Delaware and Lancaster Counties; Dauphin and Perry Counties. August—September.

This is a complex group of intergradient plants, some of which have been recognized as independent species. No definite lines of segregation can be drawn, as has been stated by Fernald (1934) and tacitly admitted by Agnes Chase (1929).

5A. Var. *circulare* (Nash) Stone ex Fernald, Rhodora 36:22 (1934).

This is fairly distinct, and may be distinguished by the possession of spikelets nearly circular in outline (less than 6/5 as long as wide), typical *P. laeve* having spikelets at least 5/4 as long as wide. Pilose and smooth indi-

viduals occur in about equal numbers in our material of var. *circulare*. Most of our specimens of typical *P. laeve* are smooth or nearly so. Individuals with pilose herbage and rather lax racemes have been called var. *pilosum* Scribn.

P. laeve ranges from Pennsylvania and New Jersey to Florida, westward to Kansas and Texas.

6. P. FLORIDANUM Michx., var. GLABRATUM Engelm.

Known in Pennsylvania only by the following collection, along the lower Susquehanna.

LANCASTER COUNTY: Haines Station, August 6, 1933. *H. Zerger*. H., P.

Southern New Jersey to Florida and Texas, mostly on the Coastal Plain, northward in the interior to Kansas.

64. PANICUM L.

1. Plants blooming twice, bearing terminal panicles in spring or summer, with reduced axillary or basal panicles later; perennial species, forming winter rosettes of short broad leaves unlike those of the culms (except in the Depauperatum Group) ..... Subgenus 1. *Dichanthelium*

1. Plants blooming only once, usually in summer or fall; annuals or perennials, not forming winter rosettes ..... Subgenus 2. *Eupanicum*

Subgenus 1. DICHANTHELIUM Hitch. & Chase.

1. Leaf blades of vernal culms elongate, 15 or more times as long as wide.
   2. Vernal blades very narrow, 20 or more times as long as wide; autumnal phase branching only from the base or lowermost culm nodes; plants not forming distinct basal rosettes in autumn ..... I. *Depauperatum Group*
   2. Vernal blades narrow, usually 15-20 times as long as wide; autumnal phase branching sparingly from the middle and upper culm nodes; plants forming distinct basal rosettes in autumn ..... II. *Bicknellii Group*

1. Leaf blades of vernal culms not elongate (i.e.,: never more than 15 and usually not more than 13 times as long as wide).
   3. Ligules prominent, densely ciliate, usually 2-5 mm. long; pubescence of culms and sheaths, if present, of long, papillose-based hairs, not mixed with short, fine puberulence.
      4. Sheaths glabrous or the lower ones somewhat pubescent; blades glabrous, ciliate at the base ..... IV. *Spretum Group*
      4. Sheaths and usually blades strongly pubescent ..... V. *Lanuginosum Group*
   3. Ligules usually inconspicuous, 1 mm. or less long, or if longer, then the sheaths or culms bearing long hairs interspersed with short, fine puberulence (best seen on middle sheaths or internodes).
      5. Spikelets with strong, conspicuous nerves.
         6. Herbage velvety throughout; culms bearing a viscid glabrous ring below the nodes; branches of the inflorescences white-spotted ..... IX. *Scoparium Group*
         6. Herbage more or less hispid, but not velvety to the touch; culms without a viscid ring below the nodes ..... VIII. *Oligosanthes Group*
      5. Nerves of spikelets not strong and conspicuous.

7. Spikelets subspheroidal at maturity, 1.8 mm. or less long; leaf blades glabrous, ciliate near the cordate base ..... VII. *Sphaerocarpon Group*

7. Spikelets elliptic to obovate at maturity.

8. Leaf blades cordate-based, 1-3 cm. wide or wider; spikelets 2.2-5.0 mm. long ..... X. *Latifolium Group*

8. Leaf blades rarely more than 1 cm. wide; spikelets not over 2.8 mm. long.

9. Culms glabrous ..... III. *Dichotomum Group*

9. Culms puberulent or pubescent.

10. Sheaths glabrous; culms crisp-puberulent ..... 23A. *P. commutatum*, var. *ashei*

10. Sheaths pubescent; at least some of the sheaths and internodes with long hairs interspersed with short, fine puberulence ..... VI. *Columbianum Group*

Subgenus 2. EUPANICUM (Godr.) Pilger
Notizbl. Bot. Mus. Berlin. **11**:243. (1931).

1. Fertile lemma smooth and shining.

2. Panicle much branched, diffuse; spikelets mostly long-pedicellate, not secund on the branches.

3. Spikelets smooth.

4. Sheaths papillose-hispid; weedy annuals ..... XII. *Capillare Group*

4. Sheaths not papillose hispid, mostly glabrous.

5. First glume short, one fourth to one third as long as the spikelet, truncate or broadly triangular; plants annual, lacking rhizomes ..... XI. *Dichotomiflorum Group*

5. First glume acuminate, at least half the length of the spikelet; plants rhizomatous perennials ..... XIV. *Virgatum Group*

3. Spikelets tuberculate ..... XV. *Verrucosum Group*

2. Panicle with few, nearly simple primary branches; spikelets short-pedicellate, appressed and secund along the branches; plants perennial; sheaths flattened ..... XIII. *Agrostoides Group*

1. Fertile lemma transversely rugose ..... *P. adspersum**

I. DEPAUPERATUM GROUP

Plants not forming distinct winter rosettes; blades very elongate, narrowly linear; culms branching from the base or the lower culm nodes only; secondary panicles small, mostly concealed among the basal leaves; spikelets strongly-nerved.

1. Spikelets 3.2-4.0 mm. long, the tips of the second glume and sterile lemma prolonged beyond the end of the fruit into an abrupt beak.

2. Blades and sheaths more or less pilose ..... 1. *P. depauperatum*

2. Blades and sheaths glabrous or nearly so, or the blades minutely scaberulous ..... 1A. *P. depauperatum*, var. *psilophyllum*

1. Spikelets 2.2-2.8 mm. long, not beaked at the tip, the second glume and sterile lemma not prolonged beyond the end of the fruit.

3. Sheaths more or less pilose ..... 2. *P. linearifolium*

3. Sheaths glabrous ..... 2A. *P. linearifolium*, var. *werneri*

1. P. DEPAUPERATUM Muhl.

Dry open woods, open ground, road banks, serpentine barrens; occasional; Monroe County to Elk and Allegheny Counties and southward. Primary panicles produced in May and June. This species is widely variable in the degree of pilosity of the leaves and sheaths. Fernald has distinguished the glabrous northern extreme as var. *psilophyllum*.

Quebec and Nova Scotia to Georgia and westward to Minnesota and Texas.

1A. P. DEPAUPERATUM, var. PSILOPHYLLUM Fernald.

This variety is more common in Pennsylvania than typical *P. depauperatum* and is found in the same types of habitats. Pike County to Centre and Fayette Counties and southward.

Novia Scotia; Megantic County, Quebec; Wisconsin, to Virginia and North Carolina.

2. P. LINEARIFOLIUM Scribn.

Dry banks and open woods, open fields, railroad embankments; fairly common through the state. Primary panicles produced in June.

Quebec to Georgia, westward to Minnesota, Kansas and Texas.

2A. P. LINEARIFOLIUM, var. WERNERI (Scribn.) Fernald.

This glabrous extreme of the species is found in the same types of habitats and blooms at the same time as typical *P. linearifolium*. It is fairly common through Pennsylvania.

Quebec to Virginia, westward to Minnesota, Missouri and Texas.

II. BICKNELLII GROUP

Plants forming distinct winter rosettes; culms sparingly branched; blades of culm leaves glabrous except for papillose cilia at the base, rather elongate, tapering to both ends; blades of basal leaves stiff, strongly papillose-ciliate; internodes of culms puberulent; panicles open, few-flowered; spikelets on elongated capillary pedicels.

3. P. BICKNELLII Nash.

Dry woods; rare; known in Pennsylvania from Luzerne, Berks, Chester, Union, Centre and Franklin Counties.

This species combines in many ways the characters of *P. depauperatum* and *P. commutatum*, var. *ashei*. In leaf proportions it is intermediate between these two. The spikelets tend to be somewhat beaked as in the former species, but the internodal puberulence resembles that of the latter. The rosette-forming habit is not possessed by the Depauperatum Group, but *P. commutatum* var. *ashei* does form a rosette. Mr. Bayard Long has suggested, on the basis of field observations, that *P. bicknellii* is a hybrid between the two previously mentioned species, and I concur in this belief. Within Pennsylvania, all known occurrences of *P. bicknellii* fall within the coincident ranges of the putative parents. One or both of the putative parents are known on the

basis of herbarium records from most of the stations for *P. bicknellii* in the state..

III. DICHOTOMUM GROUP

Plants of rather slender habit; culms in tufts, mostly glabrous, the internodes becoming much longer than the sheaths of the subtending leaves; nodes glabrous or bearded; sheaths and blades glabrous or velvety; ligules minute; panicles open; autumnal phase much-branched; secondary panicles small, few-flowered; spikelets rounded or somewhat pointed at the tip.

1. Plants erect, sometimes slender but the culms never weak and decumbent.
   2. Leaf blades velvety; nodes bearded; spikelets 1.9-2.1 mm. long; in Pennsylvania, plants of serpentine barrens ..... 5. *P. annulum*
   2. Leaf blades and sheaths essentially glabrous.
      3. Spikelets 1.5-1.7 mm. long, mostly glabrous; nodes strongly bearded ..... 4. *P. microcarpon*
      3. Spikelets usually 2 mm. or more long; nodes glabrous or the lower slightly bearded.
         4. Leaf blades erect or strongly ascending, broad; spikelets pubescent ..... 6. *P. boreale*
         4. Leaf blades spreading; spikelets glabrous or rarely puberulent.
            5. Spikelets 1.8-2.2 mm. long, rounded at the tip; sheaths without whitish flattened papillae ..... 7. *P. dichotomum*
            5. Spikelets 2.1-2.7 mm. long, pointed; sheaths bearing whitish flattened papillae ..... 8. *P. yadkinense*
1. Plants very slender; culms weak and decumbent; plants of swamps ..... 9. *P. lucidum*

4. P. MICROCARPON Muhl.

Moist woods, meadows and swamps, stream banks, clearings; fairly common through the southern 3/4 of the state. Primary panicles produced in June or early July. A specimen close to this species, but with elongated ligules and somewhat papillose-pilose sheaths and blades and pubescent spikelets, was collected at Tinicum, Delaware County, in June 1865 (Herb. U. P.). In spikelet size, bearded nodes and general habit, it resembles typical *P. microcarpon*. It may be of hybrid origin. Another specimen, in the Herbarium of the Philadelphia Botanical Club, which resembles *P. microcarpon* in all of its parts, but is considerably larger than ordinary plants of that species, and with spikelets 1.9-2.0 mm. long, has been collected at Lockport, Northampton County, R. L. Schaeffer 13127. The inflorescences are young, but the spikelets contained caryopses in various stages of development.

Massachusetts to Florida, westward to Michigan, Missouri and Texas.

5. P. ANNULUM Ashe.

Serpentine barrens, Delaware and Chester Counties. Primary panicles produced in early June.

Mostly on the Coastal Plain, from Massachusetts to Florida and Mississippi; Michigan and Missouri.

6. P. BOREALE Nash.

Swampy woods, thickets, clearings. This species is decidely northern in range and in Pennsylvania occurs mostly in the mountains, from Wayne and Northampton Counties to Schuylkill County; Lawrence County. Primary panicles in June.

Newfoundland to New Jersey, westward to Minnesota and Indiana.

7. P. DICHOTOMUM L.

Including *P. barbulatum* Michx.

This is a widespread and common grass of rocky woods, brushland and clearings, throughout Pennsylvania. Primary panicles in June.

I can find no means of separating *P. barbulatum* from this species. Various degrees of nodal pubescence are exhibited in *P. dichotomum*, and this character does not correlate with the length of the second glume. According to Hitchcock and Chase, in the N. Am. Sp. *Panicum*, *P. barbulatum* differs from *P. dichotomum* by having "usually wider blades and bearded lower nodes and fruit covered by the equal second glume and sterile lemma". Yet many of the specimens named as *P. barbulatum* by Hitchcock and Chase for their revision of *Panicum* exhibit spikelets with the tip of the fruit exposed. Indeed, this character varies within the same inflorescence. The ranges of these two "species" as reported by Hitchcock and Chase are closely coextensive, and they seem far better treated as one unit.

8. P. YADKINENSE Ashe.

Woods; rare; on the Piedmont in Montgomery, Philadelphia, Delaware and Chester Counties and at Ohiopyle, Fayette County.

Pennsylvania to Georgia, westward to Illinois and Louisiana.

9. P. LUCIDUM Ashe.

Wet meadows, swamps, *Sphagnum* bogs, wet woods; rare on the outer Piedmont; Bucks, Montgomery, Delaware, Chester and Lancaster Counties. Primary panicles in June.

Massachusetts to Florida and westward to Texas; mostly on the Coastal Plain; Michigan and Indiana.

IV. SPRETUM GROUP

Plants closely tufted; culms rather slender; sheaths and internodes glabrous or nearly so; leaf blades in our species glabrous except for a few long cilia near the base; ligules prominent, mostly 2-5 mm. long; autumnal phase bearing strict fascicles of reduced branches with small leaves and panicles.

1. Primary panicle pyramidal, 1-2 times as long as wide.....10. *P. lindheimeri*
1. Primary panicle ellipsoid, 2-4 times as long as wide.....11. *P. spretum*

10. P. LINDHEIMERI Nash.

Dry open ground, serpentine barrens, oak barrens, abandoned fields, roadsides; occasional on the Coastal Plain and Piedmont in southeastern Penn-

sylvania and known also from Monroe, Schuylkill, Dauphin, Cumberland and Centre Counties in the Delaware and Susquehanna watersheds and from Crawford, Allegheny and Greene Counties in the Ohio drainage. Primary panicles in June and early July.

11. P. SPRETUM Schult.

This is a species of the Coastal Plain, known from Pennsylvania only by the following collection:

BUCKS COUNTY: Waste ground along the Pennsylvania R.R. tracks, Bristol, June 26, 1941. *Pohl 3138.* P., A.

V. LANUGINOSUM Group

Sheaths and blades variously pubescent; blades mostly lax; ligules prominent, mostly 2-5 mm. long; autumnal phase becoming much branched; spikelets pubescent.

CHURCH, GEORGE L. 1929—Meiotic phenomena in certain Gramineae. II. Paniceae and Andropogoneae. Bot. Gaz. **88**:63-84; FERNALD, M. L. 1922—The Gray Herbarium Expedition to Nova Scotia. Contrib. Gray Herb. 63:II: *Panicum lindheimeri.* Rhodora **23**:223-28; FERNALD M. L. 1934—Realignments in the genus *Panicum.* Contrib. Gray Herb. 103. Ibid. **36**:61-87. HITCHCOCK. A. S. AND AGNES CHASE. 1910—The North American species of *Panicum.* Contrib. U.S. Nat. Herb. **15**; SHINNERS, L. H. 1944—Notes on Wisconsin grasses IV: *Leptoloma* and *Panicum.* Am. Midl. Nat. **32**:164-180.

1. Spikelets 1.4-1.9 (-2.0) mm. long; culms, sheaths, and blades more or less pubescent, or the upper portions of the plants nearly glabrous; leaf blades mostly lax and spreading ..... 12. *P. implicatum*

1. Spikelets 2.0-2.6 mm. long; culms, sheaths and blades heavily and conspicuously villous; leaf blades mostly ascending, rather firm ..... 13. *P. villosissimum*

12. P. IMPLICATUM Scribn.

Roadsides, open woods, old fields and meadows, swamps; common and widely distributed through the state. Primary panicles in late May and early June.

This species is here regarded as including the group of highly variable plants with more or less villous sheaths and blades, long ligules and small spikelets, which have been variously treated as a number of species *(P. huachuae, P. tennesseense, P. implicatum,* etc.) or as varieties of *P. lindheimeri* or *P. lanuginosum.* I regard *P. lindheimeri* as separable from this group. *P. lanuginosum,* which Fernald (1934) has applied in an inclusive sense to all of the foregoing, is here regarded as a coastal species of rather restricted ecological amplitude, not represented in our flora. While *P. implicatum* is exceedingly variable in appearance, I am quite unable to find any clearly separable groups within it. It is possible to select various forms with more or less pubescent foliage, glabrous or pubescent panicle axis, lax or firm leaves, but the majority of specimens cannot be distinguished by any stable combination of characters. Minute differences in spikelet length have often been used to differentiate "species" or "varieties" in this group. Measurement of the average length of spikelets of the vernal panicles of 220 specimens of *P. implicatum* from Pennsylvania gave the following distribution of size classes.

Average length of spikelets in mm.	Number of individuals
1.3	0
1.4	4
1.5	38
1.6	77
1.7	70
1.8	23
1.9	6
2.0	2
2.1	0

As far as spikelet length is concerned, our material thus forms a rather homogeneous group.

Hitchcock and Chase (1910, p. 142) state that the primary panicles in the subgenus *Dichanthelium* rarely perfect seed and that the secondary panicles of cleistogamous spikelets do perfect seed. In our material, the spikelets of the primary panicles frequently contained well-developed caryopses.

Church (1929) states that the pollen of the spikelets of the primary panicles of this group is completely sterile. It is difficult to reconcile his findings with the observed fertility of the primary panicles of our plants, unless apomixis be concerned. Whether or not the primary panicles perfect seed, the cleistogamy of the spikelets of the secondary or autumnal panicles would tend to cause the perpetuation of numerous local races of this species, each of which would appear quite uniform, but would differ in varying degrees from others.

13. *P.* VILLOSISSIMUM Nash.

Occasional, dry woods and serpentine barrens; on the Piedmont and Coastal Plain, Montgomery and Berks Counties to Delaware and Lancaster Counties; oak barrens of Centre County. Primary panicles in June and July.

VI. COLUMBIANUM GROUP

Culms, sheaths and undersides of leaf blades, or at least some of these, bearing two types of pubescence (long trichomes and minute or appressed fuzz) intermixed; ligules of varying lengths, from very short to 3-4 mm. long, but usually 1 mm. or less long. The double vestiture is usually best seen on midculm sheaths and internodes.

1. Spikelets 1.3-1.9 mm. long; plants mostly rather small and delicate.

2. Spikelets 1.5-1.9 mm. long; plants more or less appressed-pubescent or the lower sheaths and internodes somewhat crisp- or spreading-pubescent; larger midculm leaf blades mostly 4-8 cm. long, 4-8 mm. wide; upper surfaces of blades nearly glabrous or with a few long hairs near the base and margins ..... 14. *P. columbianum*

2. Spikelets 1.3-1.5 mm. long; plants slender, lax and delicate; at least the lower internodes and sheaths copiously spreading-pilose; blades of midculm leaves mostly 2-4 cm. long, 2-4 mm. wide, the upper surfaces bearing conspicuous long erect hairs ..... 15. *P. meridionale*

1. Spikelets 2.2-2.8 mm. long; plants rather robust; larger midculm leaf blades 6-8 cm. long, 5-8 mm. wide; sheaths and internodes moderately to heavily ascending-pilose; nodes strongly bearded ..... 16. *P. commonsianum*, var. *euchlamydeum*

14. P. COLUMBIANUM Scribn.
Including *P. tsugetorum* Nash

Occasional; roadsides, dry sterile sandy or rocky woods, oak barrens, mostly in the mountains. Plants of this species may look like depauperate forms of some other rosette-forming *Panicum* and hence be neglected by the collector. Primary panicles in June and early July.

All of our specimens of this group have been referred to *P. columbianum*. Some, with slightly larger spikelets might be referred to *P. tsugetorum*, but no real line of division betwen these two exists. In an effort to determine whether our material represented two distinct groups, the average length of spikelets was determined for each specimen by measuring five spikelets on each specimen. The results of these measurements, tabulated below, show that only one group is present.

Average length of spikelets in mm.	Number of specimens
1.5	4
1.6	12
1.7	2
1.8	1

15. P. MERIDIONALE Ashe.

Of rare occurrence in Pennsylvania, on sandy or sterile soil, in woods, on waste ground or along roadsides. June—July. Most of our collections of this species are from the southeastern portion of the state, on the Piedmont and Coastal Plain, but it has been found at scattered localities in the mountains, from Monroe and Lackawanna Counties to Fayette County.

Some intergradation occurs between this species and *P. columbianum*. Depauperate specimens of the latter (var. *thinium* Hitch.) can be assigned to either species with an equal degree of assurance.

16. P. COMMONSIANUM Ashe, var. EUCHLAMYDEUM (Shinners) Pohl.
P. pseudopubescens of American authors in part, not *P. pseudopubescens* of Nash

Common on the sand plains and beaches of Presque Isle, Erie County. Early June.

Minnesota, Wisconsin and Illinois, eastward along the Great Lakes to Presque Isle.

P. commonsianum Ashe, var. **addisonii** (Nash) comb. nov. *(P. addisonii* Nash), which is very similar to the above, but with slightly shorter spikelets (2-2.1 mm. long) and more congested inflorescences, has been collected near the Delaware River in northeastern Philadelphia. It was probably a stray from the Coastal Plain in New Jersey, where it is common.

VII. SPHAEROCARPON GROUP

Plants mostly glabrous except for ciliation on the margins of the sheaths, leaf bases, and nodes; leaf blades broad, cordate, ciliate at the base; ligules obsolete; spikelets small, around 1.5 mm. long, turgid, sub-spherical at maturity, puberulent; first glume very blunt; autumnal phase branching but sparingly; blades of the basal rosette broad, firm, strongly-nerved.

1. Primary panicle narrowly ellipsoid or cylindrical, two to four times as long as broad; blade of the uppermost culm leaf 6-18 cm. long, 9-28 mm. wide (usually 12-15 cm. x 15-23 mm.); plants (2-) 4-9 dm. tall ..... 17. *P. polyanthes*

1. Primary panicle broadly ovoid, less than twice as long as broad; blade of the uppermost culm leaf 2-6 (-9) cm. long, 4-9 (-13) mm. wide; plants 2-4 (-7.5) dm. tall ..... 18. *P. sphaerocarpon*

17. P. POLYANTHES Schult.

Occasional; creek banks, open woods, swales, roadsides, often on sandy soil; Wyoming and Dauphin Counties and southward, mostly on the Piedmont and Coastal Plain; Bedford, Fayette, and Greene Counties. Primary panicles in July.

Connecticut to Georgia, westward to Illinois, Missouri, Oklahoma and Texas.

18. P. SPHAEROCARPON Ell.

Road banks, woods, dry open ground, serpentine barrens, often on sandy soil; scattered through the southern 3/4 of the state, much more frequent on the Coastal Plain and Piedmont. Primary panicles in the latter half of June and early July. A short ligule may sometimes be present.

Vermont to Florida, westward to Kansas and Texas.

VIII. OLIGOSANTHES GROUP

Culms erect, strong; sheaths usually papillose-hispid; primary blades broad, firm; ligules very short; spikelets, in our species, over 3 mm. long, strongly-nerved, rounded at the apex.

1. Primary panicles many-flowered, open, the branches divaricate ..... 19. *P. scribnerianum*

1. Primary panicles few-flowered, narrow, the branches strongly ascending, or somewhat spreading at anthesis only.

2. Leaf blades papillose-hispid on both surfaces, the margins prominently short-ciliate nearly to the tip ..... 20. *P. leibergii*

2. Leaf blades glabrous, scabrous-margined and with a few long cilia at the base ..... 21. *P. xanthophysum*

19. P. SCRIBNERIANUM Nash.

Dry banks, serpentine barrens, old fields, thickets and open woods, often on sandy soil; Valley of the Delaware, from Pike County southward and on the Piedmont and Coastal Plain from Montgomery to Lancaster Counties, especially on serpentine; Luzerne, Centre, and Erie Counties. Primary panicles in late May and June.

This species is found through most of the United States except the far southeastern states.

20. P. LEIBERGII (Vasey) Scribn.

This is a prairie species, collected only once in Pennsylvania. The specimen is cited below.

CENTRE COUNTY: Limestone outcrop at west edge of State College, July 10, 1941. *H. A. Wahl 1035a.* P., S.

New York and Pennsylvania, westward to North Dakota and Kansas.

21. P. XANTHOPHYSUM Gray.

Sandy soil and open rocky oak or pine woods; occasional, Pike and Susquehanna Counties to Monroe and Luzerne Counties; Lycoming County. Primary panicles in June or early July.

Quebec to West Virginia, westward to Minnesota.

IX. SCOPARIUM GROUP

In our species, tall coarse plants with velvety-pubescent sheaths, blades, and culm internodes; nodes bearded, with a glabrous viscid ring below; ligule short, ciliate; inflorescence open, the branches bearing numerous whitish viscid splotches.

22. P. SCOPARIUM Lam.

In Pennsylvania, this species is confined to the Coastal Plain meadows along the Delaware River in Delaware County. It has not been collected for many years and its habitats may now have been destroyed. Primary panicles in late June and July.

Massachusetts to Florida and Texas, mostly on the Coastal Plain; northward in the interior to Kentucky, Arkansas and Oklahoma.

X. LATIFOLIUM GROUP

Including *Commutata* and *Latifolia* of Hitchcock, Man. Gr. U. S. 1935.

Plants mostly rather large; leaf blades cordate-based, not elongated, usually one to three cm. wide (5-12 mm. in *P. commutatum,* var. *ashei);* ligules obsolete or nearly so; spikelets 2.2-5.0 mm. long.

There seems to be no clear distinction between the two groups *Commutata* and *Latifolia* as used by Hitchcock. Spikelet size, used as a key character by Hitchcock, will not satisfactorily differentiate the two groups. *P. leibergii* may be sought here, and has been included in the key.

1. Spikelets 2.2-3.0 mm. long.
   2. Sheaths, especially those of the leaves of branches, more or less papillose-hispid
      3. Spikelets 2.7-3.0 mm. long; secondary panicles mostly hidden in the sheaths or only the apex exposed; leaf blades broadly lanceolate ..... 24. *P. clandestinum*
      3. Spikelets 2.2-2.8 mm. long; secondary panicles somewhat exserted; leaf blades linear-lanceolate ..... 25. *P. recognitum*
   2. Sheaths not papillose-hispid.
      4. Leaf blades broad, 12-25 mm. wide, often thin and weak; culms usually glabrous or nearly so; herbage green ..... 23. *P. commutatum*
      4. Leaf blades narrower, 5-12 mm. wide, usually firmer in texture than in the preceding, often purplish; culms crisp-puberulent, usually purplish ..... 23A. *P. commutatum,* var. *ashei*

1. Spikelets 3.4-5.0 mm. long.
   5. Nodes glabrous or nearly so.
      6. Spikelets 3.4-3.7 mm. long; leaf blades glabrous or nearly so, ciliate near the base, 1-3 cm. wide; sheaths glabrous or nearly so .....26. *P. latifolium*

      6. Spikelets 3.4-4.2 mm. long; blades more or less papillose-pubescent on both surfaces, short-ciliate nearly to the tip, rarely over 12 mm. wide; sheaths prominently papillose-pilose .....20. *P. leibergii* (See Oligosanthes Group)

   5. Nodes heavily bearded; spikelets 4 mm. or more long.
      7. Sheaths glabrous or nearly so .....27. *P. boscii*
      7. Sheaths downy .....27A. *P. boscii*, var. *molle*

23. P. COMMUTATUM Schult.

Occasional; woods and stream banks, often on sandy soil; southern Pennsylvania, from Northampton, Schuylkill, Centre and Allegheny Counties southward. Primary panicles in June.

Massachusetts and New York to Florida, westward to Michigan and Texas.

23A. P. COMMUTATUM, var. ASHEI (Pearson) Fernald.
P. ashei Pearson

Dry oak woods, clearings, brushy mountain sides, dry road banks, often on sandy soil; fairly common through the southern 3/4 of the state. Primary panicles in June.

A few plants intermediate between *P. commutatum* var. *ashei* and *P. boscii* have been collected near Plowville, Berks County, in a stand of these two species. The intermediate plants have somewhat the aspect of the former, as well as the forking branching and internodal crisp puberulence of that variety. In the bearding of the nodes and the shape of the spikelets they resemble *P. boscii*, but the spikelets are about 3.5 mm. long, too short for that species. All spikelets examined were sterile. These plants are probably hybrids of the two species mentioned. I am indebted to Mr. Bayard Long for information on their occurrence. The specimens in question are cited below.

BERKS COUNTY: One plant along road about 1 mi. e.n.e. of Plowville, August 12, 1945. *Hans Wilkens 7669-a.* A.; 1 mi. slightly n.e. of Plowville, dry soil on a roadside bank, July 22, 1944. *W. C. Brumbach 3793.* A.

Massachusetts to Florida, westward to Michigan, Missouri and Oklahoma.

24. P. CLANDESTINUM L.

Roadsides, old fields, creek banks, thickets and woods; one of our commonest species of this genus throughout Pennsylvania. Primary panicles in June and July.

Nova Scotia and Quebec to Florida, westward to Iowa and Texas.

25. P. RECOGNITUM Fernald in Rhodora 40: 331. 1938.

Swales, open grassy places, woods; rare and local. Primary panicles in

June and early July. This species is under strong suspicion of being composed of hybrids of *P. clandestinum* and *P. microcarpon*, with which it has been found growing. Cytogenetic investigation should be very revealing. Pennsylvania records are cited below.

MONTGOMERY COUNTY: Dry woods near Ashbourne Rd., below Harrison Ave., Elkins Park, July 1, 1917. *Bayard Long 16507*. A.; Wooded slope along Tacony Creek near Ashbourne Road or Mill Road, Elkins Park, July 30, 1917. *Bayard Long 17014*. A.; CHESTER COUNTY: Kennett Square, July 4, 1903. *Witmer Stone 5305*. A.; LANCASTER COUNTY: July 9, 1904. *J. J. Carter*. A.

Rhode Island; southern New Jersey and southeastern Pennsylvania.

26. P. LATIFOLIUM L.

Roadsides, thickets, woods, banks of streams, shores of ponds; common throughout Pennsylvania. Primary panicles in June. Some specimens from Pennsylvania show more or less puberulence on the leaves and nodes, especially near the base of the plant. There is no apparent correlation of this character with geographic distribution within the state. These individuals are somewhat intermediate between *P. latifolium* and *P. boscii*, but because of their small spikelets, are referred to the former species.

Quebec and Maine to North Carolina, westward to Wisconsin and Kansas.

27. P. BOSCII Poir.

Woods and cut-over slopes, riverbanks; through the southern half of Pennsylvania, more common on the Piedmont and Coastal Plain. Primary panicles in June.

Massachusetts and New York to Florida, westward to Wisconsin and Texas.

27A. P. BOSCII, var. MOLLE (Vasey) Hitch. and Chase.

This is the pubescent extreme of the species. Many intergrades between this and typical *P. boscii* occur. The variety has the same range, habitats and date of anthesis as typical *P. boscii*, and is somewhat more common in Pennsylvania than the latter.

XI. DICHOTOMIFLORUM GROUP

Much-branched weedy annuals, bearing terminal and numerous axillary panicles. Spikelets glabrous, rather appressed along the branches of the panicle; first glume very short, blunt and sometimes slightly angled or shouldered.

28. P. DICHOTOMIFLORUM Michx.

This is an abundant and aggressive weed of waste ground and disturbed soil, roadsides and city streets, river shores, pond margins, pastures and meadows; common through Pennsylvania.

Fernald, in Rhodora 38:387 (1936) has adopted the name *P. dichotomiflorum*, var. *geniculatum* (Wood) Fernald for a supposed New England and coastal variety of this species. He distinguished this variety as possessing geniculate stems, inflated lower sheaths, and reflexed panicle branches, whereas

typical *P. dichotomiflorum* was said to possess more ascending culms, sheaths which are little or not at all inflated, and ascending panicle branches.

Examination of eighty-two sheets of *P. dichotomiflorum* from Nova Scotia, New England and Pennsylvania in the Herbaria of the Philadelphia Botanical Club and the University of Pennsylvania failed to reveal any such clear cut differentiation. The specimens examined showed the following assortment of characteristics.

	Panicle branches ascending	divaricate or reflexed Panicle branches
Sheaths not inflated	Type I. 35 specimens	Type II. 7 specimens
Sheaths inflated	Type III. 36 specimens	Type IV. "var. *geniculatum*" 4 specimens

Evidently the characteristics cited by Fernald appear in all possible combinations and cannot be used to distinguish a definite "coastal type" from the bulk of this species. Of the specimens examined, types I and II were generally thin and small, often depauperate forms, often from dry or sterile habitats, dry vacant lots, quarries or roadsides. They often showed considerable red or purple coloration, indicative of certain mineral deficiencies. Large, vigorous plants usually were green and had inflated sheaths. Individuals approximating "var. *geniculatum*" were few. It has therefore been deemed best to maintain *P. dichotomiflorum*, at least in our area, as an undivided entity.

Nova Scotia and Maine to Florida, westward to Wisconsin, Nebraska and Texas; rarely farther west.

XII. CAPILLARE GROUP

Weedy annuals, with papillose-hispid sheaths. Panicles open, mostly many-flowered; spikelets glabrous, acute to acuminate; first glume acute, one- to two-thirds as long as the spikelet; fruit smooth, stramineous to olivaceous, reddish or brown.

1. Spikelets less than 3.5 mm. long; panicle branches slender; fruit stramineous.
   2. Spikelets slender-acuminate; second glume and sterile lemma with definite prolonged tips.
      3. Terminal panicle narrowly ellipsoid, usually not more than one-third the height of the plant; plants slender, usually 2.5-4 dm. tall; pulvini of the lower panicle branches glabrous ..... 29. *P. flexile*
      3. Terminal panicle ample, broadly ovoid, many-flowered, as much as half the height of the plant; plants coarse, usually 4-10 dm. tall; pulvini of lower panicle branches hispid.
         4. Base of the terminal panicle included in the sheath of the uppermost leaf ..... 32. *P. capillare*
         4. Base of the terminal panicle exserted ..... 32. *P. capillare*, var. *occidentale*
   2. Spikelets acute or rarely short-cuspidate, never slender-acuminate; terminal panicle usually not over one-third the height of the plant.
      5. Plants large, coarse, usually 3.5-5.5 dm. tall; larger leaf blades 5-11 mm. wide, usually 10-20 cm. long; panicles ellipsoid, not diffuse; spikelets

appressed, sub-racemose along the panicle branches; pulvini of main panicle branches glabrous ..... 30. *P. gattingeri*

5. Plants small, more delicate, usually 1.5-4. dm. tall; culms slender; leaf blades usually 2-5 mm. wide, 4-9 cm. long; panicles ovoid, rather diffuse; spikelets tending to be clustered in twos or threes at the ends of the panicle branches; pulvini of main panicle branches usually hispid ..... 31. *P. philadelphicum*

1. Spikelets 4.5 mm. or more long; panicle branches stout, drooping; fruit straw-colored, reddish or brown ..... 33. *P. miliaceum*

29. P. FLEXILE (Gatt.) Scribn.

Moist or dry fields or meadows, margins of streams, limestone quarries; mostly in limestone areas. In Pennsylvania, this species has been found mostly on the Piedmont from Northampton County to Delaware County, westward to Schuylkill and Lancaster Counties; Bedford and Erie Counties. September and October. Rare individuals of this species show scaberulous-nerved spikelets and hairy pulvini. They are readily separated from specimens of *P. capillare* by their smaller panicles and more slender habit of growth.

New York to Florida, westward to South Dakota and Texas.

30. P. GATTINGERI Nash.

Roadsides, fields, shores and gardens; a coarse and weedy species resembling *P. capillare* and often growing with it. *P. gattingeri* is probably common through the state, but most of our records are from the southern half, especially on the Coastal Plain and Piedmont. August to October.

New York to North Carolina and westward to Minnesota and Iowa.

31. P. PHILADELPHICUM Bernh.

Including *P. philadelphicum*, var. *tuckermani* of Steyermark and Schmoll; not *P. tuckermani* Fernald

Sandy soil, dry fields and open woods, waste ground; probably common through the state, but most of our records are from the southern half, especially on the Coastal Plain and Piedmont. August to October.

This common and weedy plant of the eastern United States is often confused with *P. tuckermani* Fernald, which it resembles. *P. tuckermani* is a northern species, largely confined to New England and Eastern Canada, and apparently not entering Pennsylvania. Keys which purport to separate these two species on the basis of *P. philadelphicum* having hispid pulvini and *P. tuckermani* having glabrous pulvini have no doubt caused much of this confusion. The pulvini of *P. philadelphicum* vary from quite hispid to nearly glabrous.

Connecticut to Georgia, westward to Minnesota and Texas.

32. P. CAPILLARE L. Witchgrass.

Witchgrass is a coarse weed of fields, river shores, gardens, roadsides and disturbed soil generally; common through the state. August to October. The mature panicle may break off and become a "tumbleweed".

32A. P. CAPILLARE, var. OCCIDENTALE Rydb.

Closely resembling the above and found in the same types of habitats. The plants are generally smaller and "neater" than those of typical *P capillare*.

33. P. MILIACEUM L. Proso Millet.

Waste ground, a stray from cultivation. August and September.

XIII. VIRGATUM GROUP

Tall strong rhizomatous perennials; spikelets glabrous, acuminate; lower floret frequently staminate.

NIELSON, ETLAR. 1944—Analysis of Variation in *Panicum virgatum*. Journ. Ag. Research **69**:327-353.

34. P. VIRGATUM L. Switchgrass.

Thickets, moist banks, gravelly river shores, railroad embankments, sandy beaches; fairly common through Pennsylvania, mostly along the valleys of the larger streams. Late June—mid-September.

Quebec to the Rocky Mountains and southward to Mexico, Central America, and the Antilles.

Nielson has shown that *P. virgatum* is exceedingly variable in both its morphology and cytology. While numerous varieties have been proposed under this species, it seems doubtful, in view of Nielson's findings, that these or even a much larger number of sub-specific designations could adequately describe the actual complexity of variation in this species. For this reason, no attempt will be made here to divide *P. virgatum* into lower categories.

XIV. AGROSTOIDES GROUP

Erect perennials with keeled sheaths; ligules membranaceous, erose or ciliate; spikelets glabrous, mostly disposed along the lower sides of the rather simple panicle branches, often more or less falcate.

1. Plants rhizomatous; spikelets falcate, set at an angle to the pedicels .....38. *P. anceps*
1. Plants lacking rhizomes; spikelets scarcely falcate, set straight on the pedicels.
2. Ligule strongly ciliate, usually 2-3 mm. long; leaf blades very elongate, narrow .....37. *P. longifolium*

2. Ligule membranaceous, erose, less than 1 mm. long.
3. Fruit with a pronounced stipe; spikelets slender, acuminate .....36. *P. stipitatum*
3. Fruit sessile; spikelets acute.
4. Panicle open, the primary branches ascending or spreading; spikelets usually 1.8-2.2 mm. long .....35. *P. agrostoides*

4. Panicle condensed or spikelike, the primary branches erect or the lowe somewhat spreading; spikelets usually 2.2-2.5 mm. long .....35A. *P. agrostoides*, var. *condensum*

35. P. AGROSTOIDES Spreng.

Moist shores and meadows, swamps, alluvial mud flats; from Monroe, Lackawanna, Clearfield and Fayette Counties southward; fairly common on

the Piedmont and Coastal Plain, scattered in the mountains. July—September.

Maine to Florida, westward to Michigan, Kansas and Texas; California.

35A. P. AGROSTOIDES, var. CONDENSUM (Nash) Fernald.

This variety is mostly confined to ditches, mud flats and swales, on the Coastal Plain from New Jersey to Florida and Texas. The only Pennsylvania record is based upon the following specimen.

FRANKLIN COUNTY: Chambersburg, August 21, 1897. *T. C. Porter.* U.S.

36. P. STIPITATUM Nash.

Wet meadows, sandy shores and low thickets; occasional on the Coastal Plain and Piedmont in southeastern Pennsylvania and in the Monongahela-Allegheny watershed in southwestern Pennsylvania; Franklin, Clearfield and Crawford Counties. July—September.

Connecticut and New York to Georgia, westward to Missouri and Texas.

37. P. LONGIFOLIUM Torr.

Occasional, moist meadows, thickets or swales; on the Piedmont and Coastal Plain from Lehigh and Berks Counties to Philadelphia and Delaware Counties. July—October.

Mostly on the Coastal Plain, from Massachusetts to Florida and Texas.

38. P. ANCEPS Michx.

Open grassy places, moist banks, woods, especially on sandy soil; common on the Piedmont and Coastal Plain, from Northampton County to Dauphin County and southward; not known west of the Susquehanna River. July—September.

New Jersey to Florida, westward to Kansas, Oklahoma and Texas.

XV. VERRUCOSUM GROUP

Glabrous annuals; spikelets tuberculate, obscurely-nerved.

39. P. VERRUCOSUM Muhl.

Stream banks, moist sandy or peaty ground and recently disturbed soil; restricted mostly to the Coastal Plain in southeastern Pennsylvania; Berks, Huntingdon and Bedford Counties; apparently rare. Late August—early October.

Massachusetts to Florida and Texas, mostly on the Coastal Plain; Indiana, Ohio and Tennessee.

65. ECHINOCHLOA Beauv.

FERNALD, M. L. 1915—Michaux's *Panicum muricatum*. Rhodora **17**:105-7; FERNALD, M. L. AND LUDLOW GRISCOM. 1935—Three days of botanizing in southeastern Virginia. Contrib. Gray Herbarium 107. Ibid. **37**:136-7; HITCHCOCK, A. S. 1920—The North American species of *Echinochloa*. Contrib. U.S. Nat. Herbarium **22**:133-53; WIEGAND, K. M. 1921—The Genus *Echinochloa* in North America. Rhodora **23**:49-65.

1. Second glume not awned; sterile lemma awned or awnless; fruit ovoid, usually 1.9-2.2 times as long as broad.
   2. Spikelets copiously hispid with stout spreading spines arising from yellowisn papillae ..... 2. *E. pungens*
   2. Spikelets hispid with slender, more or less appressed spines, their bases not prominently papillose, or merely pubescent, without spinulose hairs ..... 7. *E. crusgalli*

1. Second glume with an awn usually several mm. long; sterile lemma usually long-awned; fruit elliptical, 2.4-3.0 times as long as broad.
   3. At least the lower sheaths papillose-hispid ..... 3. *E. walteri*
   3. All sheaths glabrous ..... 3. *E. walteri*, f. *laevigata*

1. E. CRUSGALLI (L.) Beauv. Barnyard Grass.

Common; roadsides, waste ground, fields, thickets, ditches, meadows, gardens, around habitations; scattered through the state. August—October.

This and the other species of this genus are exceedingly variable. Numerous varieties and forms based on presence or absence of awns, character of the pubescence of the spikelet, etc., have been proposed. All of these intergrade and cannot be satisfactorily distinguished. An awnless form of this species, with dense panicles of chocolate brown spikelets is the so-called "billion dollar grass" (var. *frumentacea* (Roxb.) Wight). This is cultivated and has been reported as an escape. Some authors believe that while *E. crusgalli* is an introduction, *E. pungens* is native in America. Where two such very similar species are so common and widespread in the same area, it would seem very difficult to prove such a contention; other explanations are possible and have not been excluded.

2. E. PUNGENS (Poir.) Rydb.
E. muricata (Michx.) Fernald

Alluvial thickets, shores of lakes and ponds, water holes, roadsides, old fields; scattered through the state, apparently less common than the preceding species. August—September.

Maine to Florida, westward to Washington, California and northern Mexico.

3. E. WALTERI (Pursh) Nash.

Rare; tidal marshes and filled ground along the Delaware Estuary in Bucks and Philadelphia Counties. September. Our few specimens are mostly incomplete and several may represent f. *laevigata* Wiegand. Several are awnless, which is very unusual for this species.

Coastal marshes from New Hampshire to Florida and Texas, inland about the Great Lakes and in the Mississippi River Valley.

66. SETARIA Beauv.

1. Bristles of the panicle upward-barbed; lower internodes of the dense panicle concealed by the spikelets.
   2. Sheaths with a membranaceous entire margin, not ciliate; fertile lemma strongly rugose.

3. Culms tufted, from a fibrous root system; plants annual .....1. *S. lutescens*
3. Culms arising separately from a knotted, much-branched rhizome; plants perennial .....2. *S. geniculata*

2. Sheaths ciliate on the margins.
4. Spikelets falling entire, the fruit remaining covered by the glumes and sterile lemma.

5. Leaf blades glabrous above; spikelets 1.9-2.2 mm. long .....4. *S. viridis*
5. Leaf blades loosely pubescent above; spikelets 2.6-2.9 mm. long ..... 6. *S. faberii*

4. Spikelets disarticulating above the glumes, the fruit shelling out of the glumes and sterile lemma at maturity, leaving these attached to the panicle; cultigen .....5. *S. italica*

1. Bristles of the panicle downward-barbed, adhering to objects when brushed upward; lower internodes of panicles usually exposed between the somewhat distant verticils .....3. *S. verticillata*

1. S. LUTESCENS (Weigel) F. T. Hubb. Yellow Foxtail.

Common; fields and gardens, roadsides and disturbed soil generally, throughout the state. Late July—October.

New Brunswick to Florida, westward to South Dakota and New Mexico; Pacific Coast States. Introduced from Europe.

2. S. GENICULATA (Lam.) Beauv.

Occasional in moist meadows and thickets and on serpentine; confined to the Coastal Plain and Piedmont. July—September.

Massachusetts to Florida and New Mexico, north in the interior to Illinois and Kansas; California.

3. S. VERTICILLATA (L.) Beauv. Bristly Foxtail.

A common weed in gardens and along city streets, but apparently not often collected. Most known stations for this species in Pennsylvania are on the Piedmont and Coastal Plain; also in Lackawanna, Centre, Bedford and Allegheny Counties. *S. verticillata,* var. *ambigua* (Guss.) Parl. has the bristles upward-barbed but otherwise closely resembles the typical form and may rarely occur with it. June—October.

Massachusetts to North Dakota and California, southward to Louisiana and Alabama. Introduced from Europe.

4. S. VIRIDIS (L.) Beauv. Green Foxtail.

Common; cultivated fields and gardens, roadsides and waste places, probably throughout Pennsylvania on disturbed soil, but records are mostly lacking from the northernmost tier of counties. July—September.

Introduced from Europe and now found throughout the United States, and from Newfoundland to British Columbia.

5. S. ITALICA (L.) Beauv. Millet.

Cultivated occasionally and rarely escaping to roadsides and waste places.

This species is presumably derived from *S. viridis* and intermediate forms often occur among escapes. July—September.

6. S. FABERII Herrm. Beitrage Biol. Pflanzen 10:51. (1910).

Cornfields, roadsides, dumps, disturbed soil generally; now common on the Piedmont and Coastal Plain in southeastern Pennsylvania and extending into the Ridge and Valley Province in Bedford and Lycoming Counties. This species, a recent introduction in this country, is apparently extending its range rapidly in Pennsylvania. It resembles *S. viridis*, but the plants are usually much larger, and the panicle nods from near its base, that of *S. viridis* being nearly erect or the upper portion slightly nodding. *S. faberii* thrives in the rich, disturbed soil of cornfields; it apparently does not compete well with established perennial vegetation. It will probably become a dangerous weed on clean-tilled crop lands. July—October.

Southeastern Pennsylvania and southern New Jersey to North Carolina, Tennessee and Kentucky; Massachusetts; Missouri and Nebraska. Introduced from Asia.

67. PENNISETUM L. Rich.

P. ALOPECUROIDES (L.) Spreng.

Escaped from cultivation; known in Pennsylvania only by the following record. Introduced from China.

BERKS COUNTY: Abandoned field, alt. 240 ft., 5/8 mi. s. of Wyomissing, September 5, 1943. *D. Berkheimer 4228*. P., A.

68. CENCHRUS L.

1. Burs, including the spines, usually under 10 mm. broad; spines usually somewhat exposed side nearly to the base; plants of the interior ..... 1. *C. pauciflorus*
1. Burs, including the spines, usually 10-17 mm. broad; spines usually divaricate; body of the bur usually conspicuously long-pilose, without an opening down the exposed side; plants of coastal dunes, rarely adventive in the interior ..... *C. tribuloides**

1. C. PAUCIFLORUS Benth. Sandbur.

C. longispinus (Hack.) Fernald

Sandy soil, waste places, railroad embankments, paths, sand bars and non-maritime dunes; mostly on the Coastal Plain and Piedmont in southeastern Pennsylvania; Lackawanna, Luzerne, Northumberland, Dauphin, Allegheny, Erie and Beaver Counties. Sandbur is very sparingly represented from Pennsylvania in herbaria. The horridly spiny character of the bur makes the plant very unpleasant to handle and no doubt accounts for the paucity of records; this species is probably much more widespread within our area than the available spevimens indicate. July—September.

Maine to Oregon, southward throughout the United States; Mexico, tropical America; southern South America.

69. MISCANTHUS Anderss.

M. SINENSIS Anderss. Eulalia.

Frequent in cultivation and showing considerable ability to become established in the wild around Philadelphia, on the Coastal Plain and Piedmont in Berks, Bucks, Montgomery, Philadelphia, Delaware and Chester Counties. *Var. variegatus* Beal, which has the leaf blades longitudinally banded with white, may be encountered. September—October.

Massachusetts to West Virginia and North Carolina; Mississippi and Texas.

70. ERIANTHUS Michx.

E. SACCHAROIDES Michx. Plumegrass.

E. giganteus (Walt.) Muhl. According to Hitchcock. Man. Gr. U.S. 1935
E. saccharoides, var. *compactus* (Nash) Fernald, Rhodora **45**:252. 1943

Rare; on the Coastal Plain and lower Piedmont in Bucks and Chester Counties.

New York to Florida and Texas, mostly on the Coastal Plain, northward in the interior to Kentucky; Cuba.

71. EULALIA Kunth.

E. VIMINEA (Trin.) Kuntze, var. VARIABILIS Kuntze.

Moist ground, meadows and thickets; in Pennsylvania, confined to Berks and Chester Counties. This is a delicate little grass with thin culms which become decumbent and root freely at the nodes. It is not the "Eulalia" of the horticulturists, which is *Miscanthus sinensis*.

Sparingly introduced in the eastern United States, from Pennsylvania to Alabama and Tennessee.

72. ANDROPOGON L.

FERNALD, M. L. 1943—Why not *Andropogon gerardi*? Contrib. Gray Herbarium 148: 4. Rhodora **45**:255-58; FERNALD, M. L. AND LUDLOW GRISCOM. 1935—Three days of botanizing in southeastern Virginia. Contrib. Gray Herbarium 107. Ibid. **37**:138-147; HUBBARD, F. TRACY. 1917—*Andropogon scoparius* in the United States and Canada. Ibid. **19**:100-05.

1. Racemes solitary on each peduncle, mostly exserted ..... 1. *A. scoparius*

1. Racemes 2-several on each peduncle.
  2. Pedicellate spikelet staminate, well developed, similar to the sessile spikelet; pedicel flattened, widened upward; racemes not feathery, 2-7 on each peduncle ..... 2. *A. furcatus*
  2. Pedicellate spikelet sterile, reduced to a small rudiment or nearly lacking, the pedicel filiform, not widened upward; racemes 2-4 on each peduncle, feathery.
    3. Inflorescences terminal and axillary along the culm, not aggregated into a cluster ..... 3. *A. virginicus*
    3. Inflorescences mostly aggregated into a bushy terminal cluster.
      4. Upper internodes of the culm very short, mostly heavily white-bearded, much exceeded by and concealed in the broad, inflated, smooth, nearly bladeless upper sheaths, which mostly enclose the inflorescences, forming a fan-shaped cluster ..... 4. *A. elliottii*

4. Upper internodes glabrous or only slightly bearded near the apex; upper sheaths scabrous, narrow, not inflated; inflorescences exposed, in a dense obconical or corymbiform terminal cluster ..... 3A. *A. virginicus*, var. *abbreviatus*

1. A. SCOPARIUS Michx. Little Bluestem.

Old fields, railroad embankments, roadsides, open rocky slopes and open woods; fairly common on the Piedmont, less so in the Ridge and Valley Province, and apparently lacking on the Appalachian Plateau except along the larger rivers. August—early October.

Quebec and Maine to Florida, westward to Alberta, Idaho and Arizona. Numerous varieties of this species have been proposed, but the plants intergrade so freely that the "varieties" are scarcely separable. Var. *littoralis* seems distinct, and is discussed below.

1A. A. SCOPARIUS, var. LITTORALIS (Nash) Hitch.

A. littoralis Nash

Sand beaches of Presque Isle, Erie County. This variety is distinguished by its strongly keeled lower sheaths, often strongly glaucous foliage, and conspicuously villous racemes with well-developed pedicellate spikelets. A characteristic plant of the sea-beaches of the Middle Atlantic States, var. *littoralis* is at Presque Isle associated with such other maritime species as *Ammophila breviligulata* Fernald, *Cakile edentula* (Bigel.) Hook., and *Lathyrus* japonicus Willd., var. *glaber* (Ser.) Fernald. Fernald (1935) has referred the *A. scoparius* of the Great Lakes beaches to var. *neomexicanus* (Nash) Hitch., which was originally described from the white sands of New Mexico. The close resemblance of the Presque Isle plants to those of the Atlantic beaches, and their ecological association with other maritime species make it seem far more probable that they are more closely related to the maritime plant than to one of the New Mexico deserts.

2. A. FURCATUS Muhl. Big Bluestem.

?*A. provincialis* Lam.
?*A. gerardi* Vitmen

Sandy or rocky river banks, fields, meadows, alluvial thickets, roadsides; scattered through the state, more frequent in the valleys of the major rivers and their larger tributaries. August—early October.

Quebec and Maine to Florida, westward to Saskatchewan, Arizona and Mexico.

3. A. VIRGINICUS L. Broomsedge.

Dry sterile hillsides, waste ground, meadows, old fields; on the Piedmont and Coastal Plain in southeastern Pennsylvania, extending as far north as Monroe and Lackawanna Counties; Bedford County; as far north as Indiana and Butler Counties in the western Counties; absent or nearly so from limestone areas. August—October.

Massachusetts to Florida, westward to Kansas and Texas. This species is quite variable. Numerous varieties and forms have been distinguished, mostly on the basis of the shape of the inflorescence. Of these, we have the following well-marked extreme.

3A. A. VIRGINICUS, var. ABBREVIATUS (Hack.) Fernald.

A. glomeratus (Walt.) B.S.P.

Swales, meadows, swamps; rare; Coastal Plain and Piedmont, in Berks, Bucks, Delaware, Chester and Lancaster Counties. Sandy soil and crevices of sandstone, mountain bogs at about 2000 ft. elevation, Somerset and Fayette Counties.

Mostly on the Coastal Plain, from Massachusetts to North Carolina.

4. A. ELLIOTTII Chapm.

Rare; dry open slopes and old fields, quarries; Bucks, Montgomery, Philadelphia, Delaware, Chester and Lancaster Counties. September—October.

New Jersey to Florida and Texas, north in the Mississippi drainage to Missouri and Indiana.

73. SORGHUM Moench.

KARPER, K. E. AND A. T. CHISHOLM. 1936—Chromosome numbers in *Sorghum*. Am. Jour. Bot. **23**:369-74.

1. Culms usually 1-several cm. thick, resembling cornstalks; leaf blades 2-several cm. wide; inflorescence usually very congested, the branches short, densely-flowered; spikelets very turgid, at maturity usually becoming subspherical and the grains usually bursting from the glumes ..... 3. *S. vulgare*

1. Culms usually less than 1 cm. thick; plants grasslike, the leaf blades mostly 1.5 cm. wide or narrower; inflorescences open, the branches spreading and naked near the base; spikelets elliptic to ovoid, the grains not bursting from the glumes at maturity.

2. Racemes readily disarticulating, the breaks occurring at the apices of the rachis joints and pedicels; surfaces of disarticulation obliquely cup-shaped; plants rhizomatous and perennial in warm climates, with us mostly annual ..... 1. *S. halepense*

2. Racemes tardily disarticulating, the irregular breaks occurring in the internodes of the rachis joints and pedicels, leaving the stubs of the rachis joints or pedicels attached to the bases of the spikelets; plants annual, not rhizomatous ..... 2. *S. sudanense*

1. S. HALEPENSE (L.) Pers. Johnson Grass.

Sparingly introduced, in fields, on railroad embankments and waste ground; Lackawanna, Luzerne, Berks, Philadelphia, Delaware and Clarion Counties. August—October.

Johnson grass is a pernicious weed throughout the southern portion of the United States, wherever the supply of moisture is sufficient. Southern New England and New York to Florida, westward to Iowa and Texas, thence to California. Introduced from the Old World.

2. S. SUDANENSE (Piper) Stapf, in Prain, Fl. Trop. Afr. 9: 113. (1917). Sudan Grass.

S. vulgare Pers., var. *sudanense* (Piper) Hitch.

Sudan grass closely resembles the preceding species, but lacks rhizomes and is of annual habit. It is cultivated extensively for forage in the South and

West. In Pennsylvania, Sudan grass has been collected a few times in fallow fields. Introduced from the Old World.

I am unable to accept Hitchcock's disposition of Sudan grass as a member of the group of coarse and maize-like plants known as *S. vulgare*, since it resembles *S. halepense* closely in all of its characters except lack of rhizomes. Karper and Chisholm have shown that it cannot be placed in *S. halepense* because of its different chromosome number and the high degree of sterility encountered in attempts to cross *S. sudanense* and *S. halepense*. The only acceptable alternative disposition is to maintain *S. sudanense* as a separate species.

3. S. VULGARE. Sorghum.

Under this name are grouped numerous cultigens grown primarily in the warmer parts of the United States for fodder, syrup, grain, and broomstraw. The grain often forms an ingredient in stock feeds and is thereby disseminated. The plants appear in Pennsylvania only as rare waifs on waste ground and rubbish dumps.

74. SORGHASTRUM Nash.

S. NUTANS (L.) Nash. Indian Grass.

Stream banks, thickets, meadows, old fields, dry embankments; fairly frequent on the Coastal Plain and Piedmont, apparently nearly lacking from the Valley and Ridge Province and the higher portions of the Appalachian Plateau, except along the valleys of the larger streams; Presque Isle, Erie County. August—September. The anthers are conspicuous, bright yellow.

Indian grass is an important species in the tall grass prairie of central North America, extending locally westward to Manitoba, southward to Mexico and eastward in the forested regions to Quebec, Maine, and south to Florida; an extraordinarily wide distribution, paralleled by that of its companion species, *Andropogon furcatus*.

75. COIX L.

C. LACRYMA-JOBI L. Job's Tears.

Occasionally cultivated for ornament and rarely occurring as a waif on waste ground in and around Philadelphia and possibly elsewhere in the state. Introduced from the Old World.

76. TRIPSACUM L.

CUTLER, HUGH AND EDGAR ANDERSON. 1941—A preliminary survey of the genus *Tripsacum*. Ann. Mo. Bot. Gard. **28**:249-69.

T. DACTYLOIDES (L.) L. Gamagrass.

Rare; southeastern Pennsylvania, on the Coastal Plain and lower Piedmont. This species has been collected in Berks and Chester Counties; in Philadelphia and Delaware Counties along the Delaware Estuary, and in Lancaster County, along the lower Susquehanna River. Gamagrass is a close relative of maize, and like it, has separate staminate and carpellate flowers. The tall (2-3 m.) plants are to be looked for along streams in southeastern Pennsylvania. July—October.

Eastern U. S. from Massachusetts to Florida, westward to Michigan, Illinois, Nebraska and Texas.

77. ZEA L.

Z MAYS L. Maize, Indian Corn.

Maize occasionally grows from scattered seed along roadsides or in waste places, but never persists.

Excluded Species

This list contains species of the following categories: 1. Old waifs or strays, which have not been collected since 1900 and which presumably no longer occur in Pennsylvania. 2. Species which have been reported for the state in publications, but for which no voucher specimens could be located. 3. Species reported from Pennsylvania on the basis of misidentified specimens.

Bromus racemosus L. Last collected in Philadelphia in 1878. Recent specimens so named are usually depauperate forms of *B. commutatus*.

B. arenarius Labill. Collected once as a waif in Philadelphia, probably between 1870 and 1890.

Festuca myuros L. Collected in Bucks County in 1892.

F. megalura Nutt. Waif at Philadelphia, before 1900.

F. danthonii Asch. & Graebn. Collected on ballast at Philadelphia in 1878.

Puccinellia rupestris (With.) Fern. & Weatherby. Ballast waif at Philadelphia in 1876.

P. fasciculata (Torr.) Bickn. Ballast waif at Philadelphia, collected in 1857 and 1878.

P. maritima (Huds.) Parl. Ballast waif at Philadelphia, collected in 1865 and 1870.

Poa laxa Haenke. Reported by Gress from Presque Isle, on the basis of a specimen collected by J. A. Shafer in 1900. This specimen, in the Herbarium of the Carnegie Museum, is correctly named, but the plant has never been found since in Pennsylvania.

Briza minor L. Ballast waif at Philadelphia, before 1900.

Melica mutica Walt. Specimens so identified, evidently the bases of reports of this species in the state, are all *M. nitens*.

Haynaldia villosa (L.) Schur. Collected on the Centennial Grounds at Philadelphia in 1877.

Hordeum hystrix Roth. Ballast waif at Philadelphia, before 1900.

Parapholis incurva (L.) C. E. Hubb. Collected on ballast at Philadelphia in 1878.

Koeleria cristata (L.) Pers. An old specimen of this species in the Gray Herbarium is labeled "Wysox Mountain, July 1836. J. Carey." No more recent collections are known from Pennsylvania.

K. phleoides (Vill.) Pers. Ballast waif, collected at Philadelphia in 1878.

Aira caryophyllea L. Ballast waif, collected at Philadelphia in 1878 and 1879.

A. praecox L. Two old but undated specimens collected by Fiot and labeled as from Bethlehem and Bristol, are known.

Corynephorus canescens (L.) Beauv. Ballast waif at Philadelphia, collected in 1879.

Holcus mollis L. Waif at Philadelphia, collected before 1900.

Danthonia sericea Nutt. This is a species of the Atlantic Coastal Plain. Porter reported it from Lycoming County, apparently on the basis of specimens collected by J. M. McMinn, supposedly near Williamsport, in 1869. One such specimen is in the Herbarium of the University of Pennsylvania, another in the Herbarium of the Philadelphia Academy of Natural Sciences. No recent collections of this species have been made in Pennsylvania. It appears probable that the McMinn specimens bear wrong locality data.

Calamagrostis inexpansa A. Gray. Specimens from Presque Isle so named and reported by Gress are regarded as belonging to *C. canadensis*.

Agrostis spica-venti L. Waif at Philadelphia in 1878 and 1889, and in a garden at Johnstown in 1887.

Agrostis canina L. Specimens so named and reported by Hitchcock from Pennsylvania are awned forms of *A. perennans*. Of the two specimens so cited by Gress, one is very immature but is possibly *A. scabra;* the other is *A. perennans*.

Alopecurus rendlei Eig. Ballast waif at Philadelphia in 1880.

A. creticus Trin. Ballast waif at Philadelphia, before 1900.

Polypogon monspeliensis (L.) Desf. Ballast waif at Philadelphia in 1879.

Phleum subulatum (Savi) Aschers. & Graebn. Ballast waif at Philadelphia in 1879.

Sporobolus poiretii (R. & S.) Hitch. Ballast waif at Philadelphia in 1865.

S. pulvinatus Swallen. Ballast waif at Philadelphia, before 1900.

Hcleochloa alopecuroides (Pill. & Mitterp.) Host. Ballast waif at Philadelphia in 1879.

Oryzopsis miliacea (L.) Benth. & Hook. Ballast waif at Philadelphia in 1878.

Tragus raceomsus (L.) All. Ballast waif at Philadelphia in 1879.

Chloris petraea Swartz. Ballast waif at Philadelphia in 1864.

Phalaris paradoxa L. Ballast waif at Philadelphia in 1864.

P. minor Retz. Reported from Pennsylvania by Hitchcock. No specimens were found except one made from a plant cultivated by Meehan.

P. caroliniana Walt. An old specimen from the Schweinitz Herbarium, now in the Herbarium of the Philadelphia Botanical Club may have been from Philadelphia. The data are inconclusive.

Digitaria serotina (Walt.) Michx. Ballast waif, collected at Philadelphia in 1865.

Paspalum distichum L. This species was apparently once quite common near the Old Navy Yard in Philadelphia, and was collected a number of times between 1864 and 1879. No more recent collections are at hand.

Brachiaria plantaginea (Link) Hitch. Hitchcock lists this species as a ballast waif at Philadelphia and Camden. The apparent basis of this report is a single specimen in the National Herbarium, bearing two labels, one having Camden, New Jersey as the locality, and the other Philadelphia. I see no way of telling which label refers to the plant. The specimen is an old one, collected before 1900.

Panicum angustifolium Ell. An old Porter specimen of this species is labeled "Banks of the Schuylkill River below Reading, Penn. 1849." This specimen, in the Herbarium of the Philadelphia Botanical Club, is the basis for Hitchcock's inclusion of Pennsylvania in the range of this species, which has not elsewhere been found north of Cape May, New Jersey. The Porter specimen was originally labeled *P. depauperatum*. It is possible that the label was interchanged with a specimen from New Jersey.

P. clutei Nash. This species was reported by Hitchcock and Chase in The N. Am. Sp. of *Panicum*, and by Gress, from Pennsylvania. The specimens upon which these reports are based are here regarded as *P. boreale*.

P. longiligulatum Nash. Reported by Hitchcock from Bucks County. I regard the specimens upon which this report is based as belonging to *P. lindheimeri*.

P. adspersum Trin. Ballast waif at Philadelphia, collected in 1879 and 1881.

P. acroanthum Steud. This is an Asiatic species, collected in the Japanese Garden at Fairmount Park, Philadelphia, after the Centennial Exposition in 1877, and also at the old Navy Yard.

P. amarum Ell. Ballast waif at Philadelphia in 1865.

Echinochloa colonum (L.) Link. Reported by Hitchcock from ballast at Philadelphia. I have seen no specimens.

Cenchrus tribuloides L. Waif in Durham Township, Bucks County, between 1884 and 1896, and at Philadelphia in 1865.

Arthraxon hispidus (Thunb.) Makino, var. *cryptatherus* (Hack.) Honda. Waif, collected near the Japanese Bazaar, Fairmount Park, Philadelphia, in 1877, after the Centennial Exposition.

New Combinations

Elymus virginicus f. **submuticus** 549 **Panicum commonsianum** var. **addisonii** 582

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The Relation of the Spartinetum glabrae near Beaufort, North Carolina, to Certain Edaphic Factors[1]

John F. Reed

Introduction

Distinct zonation characterizes the vegetation of the tidal marshes along the North Carolina coast. The specific factors responsible for the abrupt transitions between the plant associations within the littoral region have not been determined positively.

The origin of the tidal marshes and the development of their vegetative cover have received the attention of several American investigators. Shaler (1885) and Knight (1934) ascribed the origin of marginal marshes that are protected from the direct action of waves by bars or by their location along the borders of estuaries to the silting up of quiet bodies of water to a little above the low-tide level. Such deposition permits the invasion and ecesis of the salt marsh grasses. The first marsh grass to colonize an aggraded substratum along the Atlantic and Gulf coasts is usually *Spartina glabra alterniflora*[2], occuring in nearly pure stand. Conard (1935) named this association the *Spartinetum glabrae*, a more precise designation than the "sedge association", or *Spartinetum* of Ganong (1903). This association has been recognized or described floristically from Nova Scotia, southward along the Atlantic coast, to North Carolina (Kearney 1900-1901, Ganong 1903, Davis 1910, Shreve et al. 1910, Harshberger 1909-1916, Johnson and York 1915, Nichols 1920, Wells 1928, Knight 1934, Conard 1935, Chapman 1940). It is known in the Gulf Coast region from the work of Penfound and O'Neil (1934) and Penfound and Hathaway (1938).

In almost all places where the *Spartinetum glabrae* occurs the next shoreward community is either the *Spartinetum patentis*, the *Distichlidetum spicatae*, or, on especially saline sites, the *Salicornietum ambiguae*, all of which associations are well described by Conard (1935).

Among the many factors related to vegetational zonation in salt marshes may be mentioned: (1) the relation of the associations to tide level and the consequent effects of alternate exposure and inundation (Kearney 1901, Ganong 1903, Johnson and York 1915, Nichols 1920, Wells 1928); (2) the movement of the water table and the resulting variation in aeration within the salt-marsh soils (Nichols 1920, Penfound and O'Neil 1934, Chapman 1938, Penfound and Hathaway 1938); (3) changes in relative height of ocean water

1 This is a contribution from the Duke University Marine Biological Laboratory, and also Contribution Number 205 from the Department of Botany and the Rocky Mountain Herbarium of the University of Wyoming.

2 Nomenclature is that of Gray's Manual, 7th Edition, unless authorities are given.

and marsh surface, as in an area of emerging or subsiding coast line (Shaler 1885, Davis 1910, Nichols 1920); (4) the salinity of the soil solution in which the marsh plants grow (Kearney 1900-1901, Ganong 1903, Harshberger 1909, Johnson and York 1915, Nichols 1920, Kelly 1925, Penfound and O'Neil 1934, Steiner 1934, Penfound and Hathaway 1938, Uphof 1941); (5) the osmotic pressure of the soil solution (Steiner 1934); (6) the physical character of the salt-marsh soil (Johnson and York 1915, Chapman 1942); (7) the hydrogen-ion concentration of the soil solution (Wherry 1920, Kelly 1925); (8) variations in soil moisture from one zone to another (Nichols 1920, Penfound and Hathaway 1938); (9) and the factor of competition between adjacent communities (Johnson and York 1915, Nichols 1920). It is generally conceded that zonation is caused by the combined influence of more than one of the above-mentioned factors, most of which are obviously interrelated.

It is entirely possible that the influence of salt spray is an important factor in causing marginal zonation within the salt marsh. Its importance along the sand beaches of the coast of North Carolina has already been demonstrated (Wells 1939, Oosting and Billings 1942, Oosting 1945).

The actual salinity of the soil solution near the sea has been reported as follows: 0.2 to 0.3 percent in sandy soil near the shore of the North Sea (Stocker 1928); 0.00025 to 0.03 percent in soils of the salt marshes of the New Jersey coast (Kelly 1925); and 0.25 in sandy soil just above high-tide level in Bataan Province on Luzon, Phillipine Islands (Kienholz 1928).

In his study of the salt tolerance of transplanted salt-marsh plants, Taylor (1939) found that *Spartina glabra alterniflora* grew very poorly in fresh water, and also in water of the same composition as sea water. Its best growth occurred in water of medium salinity. *Spartina patens* and *Distichlis spicata* grew best in water of comparatively low salinity as compared with *Spartina glabra alterniflora*. Oostings and Billings (1942) using phytometers in their study of dune plants found that *Spartina patens*, the only salt-marsh plant included, was not affected by daily watering with sea water.

Successional stages of vegetation within the salt marshes where active aggradation is going on, the Shaler type of marsh, correspond to the successively higher zones above open water (Ganong 1903, Nichols 1920, Wells 1928, Knight 1934, Conard 1935, Chapman 1940). In areas of a subsiding coastline retrogressive succession is known to occur, its rate and the nature of its stages being conditioned by the rate and amount of subsidence (Davis 1910, Nichols 1920). Zones of the salt marsh evident on eroding areas are not necessarily synonymous with successional stages (Conard 1935).

In this study special emphasis is placed on determining the nature of the mid-littoral association near the Duke University Marine Biological Laboratory at Beaufort, Carteret County, North Carolina. The communities encountered are classified after Conant (1935). The subterraneous development of the plants was studied and several factors of the edaphic environment analysed. The results of an attempted correlation of the various zones with certain critical environmental factors are presented.

NATURE OF THE COMMUNITIES STUDIED

The *Spartinetum glabrae* is the marginal emergent vegetation on muddy shores along the North Carolina coast. It is subjected twice daily to flooding by the tides to a depth varying from but a few inches to over a foot. The plants are frequently wetted completely by waves and spray but are not ordinarily submerged.

In the region of this study the community is a pure stand of *Spartina glabra alterniflora*. The individual plants reach their best development about half way between the low- and the high-tide levels. They decline in height and luxuriance both seaward and shoreward from near the center of the association. Each stand typically includes from 200 to 400 stalks per square meter. A sod which varies from 12 to 20 centimeters in thickness and consists of tightly interlaced rhizomes and roots is formed within the muddy substratum. A layer of silt and sand above the underground mat of subterraneous organs increases in thickness toward the upper limit of the association, an evidence of the aggrading reaction of the plants.

The *Spartinetum glabrae* is one of the major associations along the North Carolina coast, where tidal marshes cover over 56,000 acres in Carteret County alone (Perkins et al. 1938).

Several associations may be found next adjacent and shoreward from the *Spartinetum glabrae*. In the region surveyed these bordering communities may be: (1) the *Salicornietum ambiguae*, made up of *Salicornia ambigua, Salicornia europaea, Suaeda maritima, Limonium carolinianum*, and *Distichlis spicata;* or (2) the *Distichlidetum spicatae*, which is normally the species in pure stand; or more commonly (3) the *Spartinetum patentis*, including *Spartina patens* and *Juncus Gerardi* with other occasional species.

The ecotone between the *Spartinetum glabrae* and the next shoreward association is normally about one meter wide. It neatly parallels the shore, and within it there mingle quite at random individuals from the contiguous communities. The plants from the emergent community become depauperate and finally cease to exist directly above the level reached by spring tides.

SUCCESSIONAL RELATIONS

Wells (1928) reported successional features of the communities studied. The *Spartinetum glabrae* tends to enhance aggradation as sand and silt are deposited between its dense aerial stalks and within the interstices of its dense subterranean mat. Such accumulation results in raising the former mid-littoral region above ordinary tide level and permits the establishment of the more stable *Spartinetum patentis* or the *Distichlidetum spicatae*.

METHODS OF STUDY

Four stations were selected in representative examples of the *Spartinetum glabrae* located within a radius of three miles of the Laboratory, after having examined many other stands over a much larger area. Quadrats were used in determining the number of plants (stalks) per square meter.

At each station a line was established from the outermost plants of the *Spartinetum glabrae* across that association and landward through the ecotone

well into the next adjacent landward community. Along each line so established a sampling device, designed to disturb the natural condition of the soil as little as possible, was used to collect soil samples. The soil was sampled at four points within each community studied: (1) at the level of maximum development of the subterranean organs, ten centimeters below the surface, within the *Spartinetum glabrae;* (2) at a similar position and level within the ecotone where the mat of the upper littoral community was best developed; (3) within the next adjacent landward community at a similar level; and (4) at a depth of eighteen centimeters beneath the ecotone where the *Spartina glabra alterniflora* mat lay beneath the mat formed by the seaward growing plants from above.

From the soil samples collected measurements of significant physical properties of the soil were made, including the volume-weight ratio, the moisture-holding capacity, and the total air capacity. Field moisture determinations were made from a duplicate series of samples collected at low tide from the same locations as the undisturbed series. These samples were dried for 48 hours at at a temperature between 105 and 110 degrees C. in a thermostatically regulated oven. The degree of drainage was calculated by subtracting the field-moisture content at low tide from the moisture-holding capacity, assuming that complete flooding was the rule at the level of the subterraneous mats. This assumption was tested and found to be tenable. This measurement of drainage is an indication of actual air capacity of the soil between tides, and it is believed more significant than merely the measurement of total air capacity.

Along each established line at the various stations a ditch one meter wide and deeper than the rhizome-root mat was dug. This bisect provided the opportunity for study of the subterraneous organs, their distribution, and the type of soil in which they grew. Disturbed soil samples were collected from the soil removed in making the bisects and later used in determining salinity (total chloride content) of the soil solution.

The salinity of the soil solution was determined by volumetric precipitation. Two hundred grams of oven-dry soil were placed in a liter of distilled water and after 48 hours a small aliquot of the effluent was titrated against a standard silver nitrate solution using potassium chromate as the indicator. The weight of the chlorides was then calculated and expressed as percent of the soil solution.

RESULTS

THE SUBSTRATUM AND SUBTERRANEOUS PLANT DEVELOPMENT

Underlying the entire *Spartinetum glabrae* as deep as the lowest penetration of rhizomes and roots a dark layer of muck was found thoroughly permeated by the rhizome-root mat. A layer of sand about 2 centimeters thick covered the surface of the ground throughout the lower extent of the association. At the upper level of tidal action, however, this superficial covering of sand was frequently as much as 25 centimeters in thickness. The average depth of the rhizome-root mat beneath the *Spartinetum glabrae* was found to be about 10 centimeters, except where the heavier accumulation of surface sand had buried it to a depth of about 18 centimeters.

The transition region from the lower- to the mid-littoral associations coincided with the greatest accumulation of sand, and in this ecotone a distinct stratification of subterraneous organs was discovered. The mat of *Spartina glabra alterniflora* was found at a lower level than the mat formed by those plants from the upper littoral region growing seaward as the sand had accumulated. Some interlocking of these two mats was observed, but almost invariably the rhizomes and roots of *Spartina glabra alterniflora* which curved upward into the drier sandy layer were dead. Several of these dead rhizomes were traced downward to their union with living rhizomes to which were attached viable culms. The only species found to have penetrated the double layer of mats in this tension region were a few scattered individuals of *Cakile edentula, Atriplex arenaria* and *Chenopodium* sp., which occur in our region as occasional components of the next adjacent, landward associations.

THE MEASUREMENTS OF THE EDAPHIC FACTORS

The results of measuring certain physical properties of the soil, the determination of field moisture at low tide, the expressions of the salinity of the soil solution, and the calculations of actual air capacity of the soil between tides are presented in Table 1. The position at which each set of determinations was made is also indicated. For statistical treatment the samples from all four stations are combined, those from each position in one stand being averaged with those from comparable positions in the other three stands. The probable error and standard deviation of each set of determinations is also included.

It is evident from the results presented in Table 1 that the volume-weight ratio and the moisture-holding capacity of the soil at all four stations are remarkably uniform. Total air capacity at the level of the *Spartina glabra alterniflora* mat in the ecotone region was less than at either the shoreward or landward stations. Field moisture content in the intertidal period was almost identical beneath the *Spartinetum glabrae* and at both soil levels within the ecotone. The minimum field moisture content determined occurred in the communities above the ecotone. The normal amount of air in the soil during the intertidal period is reflected by the degree of drainage. It is obvious that the degree of drainage is markedly less in the soil occupied by the roots and rhizomes of *Spartina glabra alterniflora* than in that surrounding the underground organs of the higher-lying associations both in the ecotone and above it. The salinity of the soil solution was found to decrease progressively from the region of the *Spartinetum glabrae* through both levels sampled in the ecotone to a comparatively low figure beneath the fairly stable associations most remote from the open water.

In order to test the validity of the measurements of the edaphic factors presented in Table 1, those data were subjected to statistical treatment by the use of the analysis of variance (Snedecor 1946). The variation of each of the factors due to sampling at the four positions is thus contrasted with the variation of the same factors due to place. Assuming that no significant differences other than those due to chance exist between measurements of any of the edaphic factors at the various stations, exceptions proven through statistical analysis may be ascribed to place rather than to chance sampling. The

TABLE 1.—The summation of the study of edaphic factors. Each mean derived from combining samples collected at comparable positions in 4 stands of the *Spartinetum glabrae*, the ecotone, and the next adjacent landward association.

	Spartinetum glabrae 10 cm. level				Lower Mat Ecotone 18 cm. level				Upper Mat Ecotone 10 cm. level				Upper-littoral Community 10 cm. level			
	Number of Samples	Mean	p.e.	S.D.	Number of Samples	Mean	p.e.	S.D.	Number of Samples	Mean	p.e.	S.D.	Number of Samples	Mean	p.e.	S.D
Volume-Weight Ratio	12	1.28	±0.029	0.14	12	1.35	±0.018	0.09	12	1.32	±0.024	0.12	12	1.28	±0.021	0.11
Total Air Capacity per cent ..	12	9.8	±0.789	4.05	12	6.4	±0.600	3.08	12	9.1	±0.613	3.15	12	8.1	±0.601	3.09
Moisture Holding Capacity per cent ...	12	37.9	±0.944	4.83	12	36.6	±0.722	3.70	12	35.6	±0.762	3.91	12	35.6	±0.877	4.51
Field Moisture at Low Tide per cent	9	25.9	±0.796	3.53	7	25.9	±0.890	3.50	8	25.3	±0.755	3.18	8	19.3	±1.33	5.58
Degree of Drainage Between Tides	8	8.6	±0.479	2.01	8	8.8	±0.971	2.75	8	20.9	±1.45	6.12	8	21.4	±1.61	6.80
Salinity per cent of Soil Solution at Low Tide	8	0.62	±0.009	0.04	8	0.42	±0.007	0.03	8	0.32	±0.007	0.03	8	0.14	±0.005	0.02

existence of significant differences due to place may then be considered in their relation to the zonation of vegetation where such differences exist.

In Table 2 are presented the analyses of variance for each of the edaphic factors studied. The number of samples determines degrees of freedom, which are one less than the number of samples collected, since one sample must be disregarded because it might be equivalent to the mean if only one sample were taken. The degrees of freedom represent the number of independent variations possible from the mean.

The observed F is a measurement of the validity of the basic assumption, i.e. that only chance variations occur. It is the ratio of the larger mean square to the smaller mean square of the deviations from their respective means. The significance of F is determined by reference to statistical tables (Snedecor 1946), and it is expressed as significant at the one percent level, occurring once in one hundred times due solely to chance, or at the five percent level, occurring by pure chance only five times in one hundred.

The information sought is the significance of variations in each factor due to place, since the sampling was done at positions representative of vegetational zonation already described.

It is apparent from the analysis of variance that the drainage factor, which indicates both the relative amount of water leaving the soil at the various positions as well as the actual air capacity of the soil during the intertidal periods, varies significantly due to place. Likewise the salinity of the soil solution shows variation ascribable to chance only once in one hundred times, and so it may be considered a significant variation due to place.

The remainder of the edaphic factors studied failed to show variations significant at the five percent level, although the value for total air capacity barely missed significance.

TABLE 2.—Analysis of variance for the several edaphic factors studied at four positions across the *Spartinetum glabrae*, the ecotone, and the next adjacent landward community.

	Variation due to	Degrees of freedom	Summation D2	Mean Square	Observed F.
Volume-weight Ratio	sampling	44	0.613	0.014	
	place	3	0.042	0.014	1.00
Total Air Capacity	sampling	44	500.4	11.3	
	place	3	82.2	27.4	2.42
Moisture-Holding Capacity	sampling	44	799.5	18.1	
	place	3	50.3	16.8	1.08
Field-Moisture at Low Tide	sampling	28	2793.4	99.8	
	place	3	250.6	83.6	1.19
Degree of Drainage	sampling	28	332.2	11.9	
	place	3	1223.2	407.8	34.3*
Salinity of Soil Solution	sampling	28	2.29	0.082	
	place	3	0.96	0.322	3.94**

* significant at 1% level.
** significant at 5% level.

INTEGRATION AND SUMMARY

The *Spartinetum glabrae* near Beaufort, North Carolina consists of a nearly pure stand of *Spartina glabra alterniflora,* and is the marginal emergent vegetation. It does not differ appreciably from the Long Island, New York, community described by Conard (1935), nor from other mid-littoral associations along the Atlantic coast.

A well-developed mat of subterraneous organs exists beneath the plants of the association. This mat lies at an average depth of 10 centimeters in a muck-like soil, overlying which is a thin layer of surface sand.

The soil beneath the *Spartinetum glabrae* appears to be poorly drained, and with a high percentage of chlorides in the soil solution as compared with soil collected at points farther back from the mid-littoral region.

At the position normally reached by high tides there is a transition region about one meter wide, which represents the meeting place of the *Spartinetum glabrae* and the next adjacent landward community, which in this region may be either the *Spartinetum patentis,* the *Distichlidetum spicatae,* or a *Salicornietum.*

Within the ecotone the aggrading effect of tides, waves, and shore currents results in burying the mat of the mid-littoral community to an average depth of about 18 centimeters. In the lighter colored soil deposited above the muck of the former mid-littoral a mat is superimposed upon the roots and rhizomes of *Spartina glabra alterniflora* by the seaward growing species from the more stable areas above the influence of normal tidal action.

The edaphic environment within the ecotone region at the level of both subterranean mats appears to be comparable with respect to field moisture content between tides, the apparent specific gravity of the soil as revealed by volume-weight ratios, and the moisture-holding capacity. Relatively poor drainage is indicated at the level of the mat formed by *Spartina glabra alterniflora* as contrasted with conditions nearer the surface. Greater salinity of the soil solution is also indicated at the deeper level. Conditions within the ecotone, where the mat formed by *Spartina glabra alterniflora* lies, appear very similar to those surrounding the mat of the same species where it occurs alone in the mid-littoral portion of the marsh.

It seems that as aggradation occurs along the shore, a few shoots of the marsh grass from the mid-littoral region are able to survive in the ecotone, and this is a result of their underground organs continuing existence under essentially similar edaphic conditions as prevail nearer the open water. However, within the ecotone a new substratum is deposited upon the mat of the mid-littoral marsh grass, thus providing conditions which favor the seaward growth of plants from the more stable landward communities. Leaves and culms of the deeper-lying *Spartina glabra alterniflora* must push their way for six inches or more upward through a tangle of roots and rhizomes formed by the new invaders from the upper-littoral border. Such plants are thus set in direct and serious competition with each other for space to grow. The superficial layer of vegetation is favored over that which it covers, and as aggradation continues the tension zone, or ecotone moves seaward *pari passu* with the accumulation of water-lain soil and the subsequent burial of the mid-littoral mat.

Analysis of the edaphic factors beneath the *Spartinetum patentis* and the *Distichlidetum spicatae* show the essential similarity of such shoreward sites and the upper level of soil within the ecotone region which is normally invaded by plants from these associations. Beneath these higher-lying communities the soil is drier, better drained, and with a lower saline content than where *Spartina glabra alterniflora* grows.

The relative tolerance to salinity shown by *Spartina glabra alterniflora* as compared with *Spartina patens* or *Distichlis spicata* in Taylor's (1939) work with transplants is confirmed. Uphof's (1941) generalizations are both supported for this region; (1) that marginal zonation in salt marshes is caused in part, at least, by a gradient in the salt content of the soil, and (2) that *Spartina patens* and *Distichlis spicata* represents the plants associated with the next more stable associations along the landward margin of the *Spartinetum glabrae*.

The absolute salinity of the soil solution at the various positions sampled lies within the range of values reported by Stocker (1928), Kelly (1925), and Kienholz (1928).

This biometrical analysis yields evidence thoroughly in accord with the conclusions of Johnson and York (1915) who, by observational techniques alone, summarized their finding with respect to the *Spartinetum glabrae* on Long Island, New York, in part, as follows: (1) its upper limits are determined by competition with other angiosperms; (2) poor drainage favors its development; (3) a low degree of saturation of the soil with salt or brackish water is most effective in deterring the upward spread of the association; (4) competition at the upper level of the association is with species unable to endure either a prolonged submergence or a high degree of salinity of the soil solution.

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Variations in Floss Characteristics Among Plants of Asclepias syriaca L. Having Different Types of Pods[1]

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Introduction

In a previous paper Sparrow (1946) has shown that there are many different types of pods among the wild stands of *Asclepias syriaca* L. growing in Michigan. Pods were observed to vary in length and in shape, there being, however, a general tendency for short pods to be plump and long ones slender. The pod surfaces exhibited striking differences, ranging from smooth to spiny and sometimes to a very ridged condition as well. Other outstanding characteristics were observed such as a rumpled tip and very stiff spines. Sparrow (1946) considers these different pod types to be genetic entities, not mere fluctuating characteristics due to environment. These observations suggested that, correlated with the pod differences, there might be variations in certain morphological features of the floss, which would be of such magnitude as to be of importance in developing stocks, should the commercial production of milkweed floss seem advisable in the future.

A very superficial examination of a number of pods shows that they vary in the number and size of seed, that tuft length is not uniform and that all the fibers[2] within a tuft may not be the same length. A few investigators have published observations made on fiber length, fiber width, number of fibers per tuft and tuft weights (Dischendorfer, 1926; Gerhardt, 1930; Meitzen, 1862; Neish and Burns, 1921; Stevens, 1945). With the exception of the work of Stevens, the information is meagre. It is obviously based on a very limited number of observations and consequently gives no adequate idea of the variability that was encountered. Moreover, many of the observations were made on European grown material.

In considering a possible future production of milkweed floss upon a commercial scale, it would be desirable to have some preliminary information regarding those floss properties which might have some relationship to yield

1 Contribution from the Botany Department, University of Michigan No. 834. This study is a part of investigations that were conducted cooperatively by the Bureau of Plant Industry, Soils, and Agricultural Engineering, United States Department of Agriculture, Agricultural Research Administration, the Michigan State Agricultural Experiment Station, and the Department of Botany, University of Michigan, and was made under the general supervision of Professor F. K. Sparrow, University of Michigan. Grateful appreciation is expresesd for the assistance of Mary Bernard Klepper, whose services were made available in part through funds supplied by the Horace H. Rackham School of Graduate Studies, University of Michigan.

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2 The term "fiber" is used throughout this paper to indicate the individual seed hairs of the tuft or "coma."

TABLE 1.—Description of pod types.

Code No.[2]	Description of Pod[1]		
	Shape	Surface	Figure number for same or similar type in Sparrow's article (1946)
1	Plump	Numerous long slender spines	Similar to fig. 1,D
2	Plump, rumpled	Nubbins and some spines	Same as fig. 2,A
3	Plump, intermediate	Ridged, short spines	Same as fig. 2,D
4	Slender intermediate, subfusiform	Short slender spines	Same as fig. 4,H
5	Slender, subfusiform	Nearly smooth	Same as fig. 5,B
6	Lg. intermediate tending to stout and subfusiform	Some spines	Same as fig. 4,D
7	Plump	Many long spines	Similar to fig. 1,D
8	Plump	Ridged with long spines	Similar to fig. 1,H
9	Intermediate	Some spines	Similar to but smaller than fig. 4,C
10	Intermediate	Many slender medium length spines	Similar to but smaller than fig. 4,C
11	Plump	Ridged, coarse wedge-shaped spines	Similar to fig. 1,K
12	Slender, intermediate, subfusiform	Scattered spines and some nubbins	Similar to but smaller than fig. 4,H
13	Plump, intermediate	Numerous long slender spines	Same as fig. 1,H
14	Plump	Ridged, many coarse wedge-shaped spines	Same as fig. 1,K
15	Plump	Nearly smooth	Same as fig. 1,G
16	Plump, intermediate	Nubbins and short spines	Same as fig. 3,B
17	Plump	Ridged with some wedge-shaped spines	Similar to but less spiny than fig. 1,K
18	Intermediate	Broad ridges, short spines	Same as fig. 3,F
19	Plump	Nearly smooth	Similar to fig. 1,G
20	Plump	Ridged, some wedge-shaped spines	Similar to but less spiny than fig. 1,K
21	Plump, intermediate	Short spines	Same as fig. 3,A
22	Intermediate	Ridged with long slender spines	Same as fig. 2,J
23	Plump, rumpled	Ridged, many coarse spines	Similar to fig. 1,I
24	Plump	Many coarse spines	Similar to fig. 1,I
25	Plump, intermediate	Many long slender spines	Same as fig. 2,C
26	Plump, intermediate	Short spines	Similar to fig. 3,A
27	Intermediate	Ridged, coarse spines	Same as fig. 4,E
28	Slender, subfusiform	Nubbins with fairly numerous short spines	Same as fig. 5,A
29	Intermediate	Many short spines	Same as fig. 3,I
30	Intermediate	Numerous very long spines	Same as fig. 3,H
31	Plump, rumpled	Ridged, many coarse spines	Same as fig. 1,I
32	Intermediate, subfusiform	Smooth and silvery	Same as fig. 4,A
33	Stout subfusiform	Spines of moderate length and density	Same as fig. 5,C
34	Slender, subfusiform	Ridged, numerous slender spines	Similar to fig. 5,I
35	Slender, subfusiform	Nearly smooth	
36	Slender, subfusiform	Nearly smooth	Similar to fig. 5,B
37	Slender, subfusiform	Nearly smooth	only somewhat more slender
38	Slender, subfusiform	Many short spines	Similar to fig. 5,F
39	Slender, subfusiform	Many slender long spines	Same as fig. 5,I

1 Description according to Sparrow (1946) for same or similar types.

2 Nos. 1-6, Group I; Nos. 7-39, Group II. Types arranged in each group in order of increase in average length of pod.

or which might be of some importance in determining or affecting the use of the floss. For example, it would be desirable to know the range of variation that exists in *Asclepias syriaca* with regard to floss length, fiber width, number of fibers per tuft, tuft weight and floss weight per pod and also the extent to which these properties are themselves interrelated and related to certain general kinds of pods. The following paper presents information regarding the variability and relationships of these 5 floss properties. The data were gained from a detailed study of 156 pods representing 39 different pod types growing wild in Michigan.

Materials and Methods

In the autumn of 1943 and of 1944, numerous pods of *Asclepias syriaca* were collected by Professor F. K. Sparrow and the author from two regions in Michigan: (1) Washtenaw County in the southern part of the state and (2) the vicinity of Petosky, in the northern part of the Lower Peninsula of Michigan.

Each plant or each clone whose pods differed noticeably from those of another plant or clone in the same locality was considered a "pod type". It is true, however, that among wild forms absolute clonal identity could not always be established for plants having the same type of pod and growing in close proximity to one another. Absolute identification meant the digging up and tracing of rootstocks, a task which was not practical to undertake.

Of the several hundred collections, each representing a different plant or clone, 49 were selected by Sparrow (1946) as illustrative of variations in pod size, shape and external features. Nineteen of these, in addition to 20 others, were selected for a detailed study of their floss properties. These 39 types represented extreme and average conditions of pod shape, size and external features. To facilitate discussion these selected types are coded by numbers 1 to 39. A brief description of each is presented in Table 1. The 20 types not described by Sparrow are described in Table 1, in his terminology, and reference is made to similar types among his 49 types.

The 39 types are divided into two groups. Group I consists of 6 types from one locality, the Toma Farm in western Washtenaw County. In 1943 this area supported a luxurious growth of *Asclepias syriaca* and 14 clonal types were marked. Collections were made of each type and six with outstanding pod features were selected for a detailed study of the floss. In 1944, pods very similar to those of the 6 selected types were taken from the same respective locations. These Toma types are designated by code numbers 1 to 6 (Table 1), the 1944 collections being distinguished from those of 1943 by the addition of "a" to the type code number. Group II consists of 33 types collected either in 1943 or 1944, at one of several locations, including the Toma Farm. They are designated by code numbers from 7 to 39 (table 1).

The study of the floss properties was made on dry pods. After collecting, those pods not used in the pod variability study (Sparrow, 1946) were first allowed to dry nearly to the point of bursting. They were then wrapped around several times with thread to prevent complete dehiscence and stored in paper bags.

Techniques were developed for ascertaining on a pod basis, floss length, fiber width, number of fibers per tuft, tuft weight, and floss weight per pod. These will be discussed in the latter part of the paper where the individual fiber properties are considered in detail.

The number of pods examined for each property and for each type was limited to some extent by the number of pods collected (for each of the selected types) but mainly by the arduousness of the technical methods. For each type of Group I, 10 pods were studied, 5 for each year. These 5 pods may have come from 2 to 4 plants of the same clone. Three pods were studied for each of 30 types of Group II, and 2 pods for each of the other 3 types. With the exception of 9 of the 33 types comprising this group, each is represented by pods from only one plant. Data for at least 2 fiber properties were obtained from most pods and for all 5 properties from a few.

The number of seeds per pod is not uniform, the number occasionally falling below 150. Consequently, the amount of material available had to be taken into consideration in deciding upon the number of tufts that would provide an adequate sample for each property being investigated.

The sampling procedure was as follows: All the seeds with their attached tufts were emptied from the selected pod into a deep box and stirred very gently to insure a fair degree of mixing. This mixing was necessary because some relationship between the position of the seed in the pod and the length of its tuft was noted. The stirring had to be done very carefully, otherwise tufts became detached from their seeds and were broken into parts. Length determinations were made first and all of the 50 tufts required for this sample were taken from one end of the box. From 15 to 25 tufts were next set aside to supply material for fiber width determinations, for ascertaining the number of fibers per tuft, or for any other seemingly desirable observations. From the remaining tufts, 100 were selected for the weight sample. In a few instances there were less than 100 tufts left and in these cases some of the tufts from the length sample were re-used or the weight per tuft was determined upon less than 100 tufts.

The data were subjected to variance analysis and where feasible to correlation and to covariance analysis. In the analysis of the length and weight data it was necessary to consider Groups I and II separately, since Group I is represented by 10 pods per type and Group 11 by 3 pods.

Observations and Discussion

The floss of the milkweed consists of tufts of fibers attached to the blunt or micropylar ends of the extremely flattened seeds (fig. 1, A-G). The tuft is known as the "coma". Each is composed of several hundred fibers and usually has a length several times that of the seed. The seeds themselves are attached to knife-like placental ridges. Since the point of attachment is in the middle of the micropylar end the tuft straddles the placental ridge to which the seed is attached, approximately one-half of the fibers of a tuft growing along one side of the ridge and the other half along the opposite side. Each of these portions of the whole tuft will hereafter be referred to as a "half-

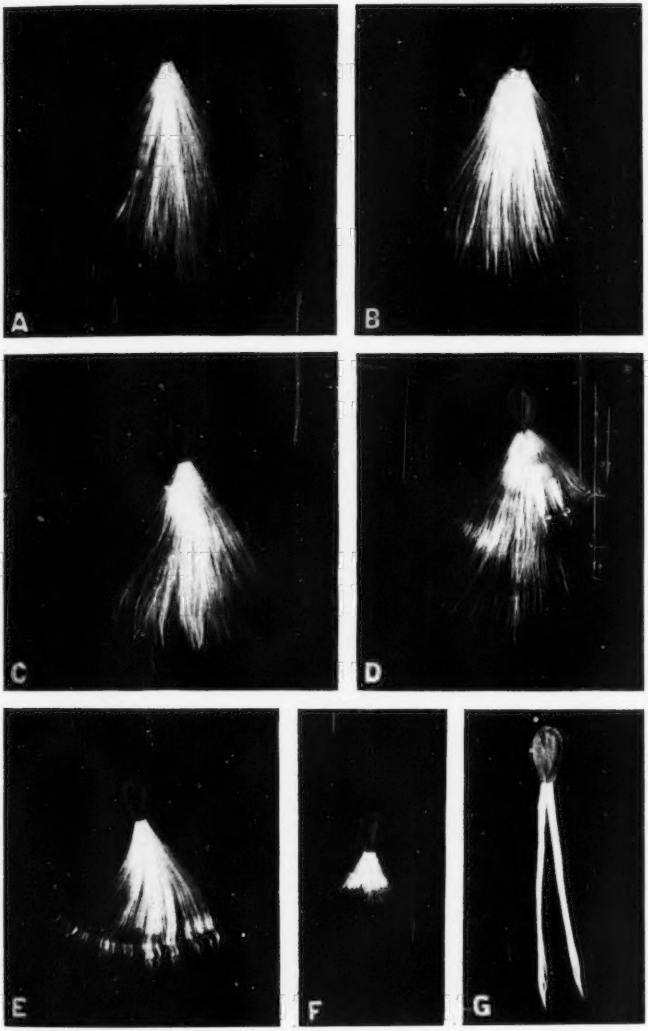

Fig. 1. Tufts of *Asclepias syriaca;* A-F, from mature pods: A, C, D, and F from one pod, B and E each from one of two others. A. Tapering tuft with little variation in fiber length; B. Tapering tuft with greater variation in fiber length; C. Truncate tuft (impeded?), fibers apparently all the same length; D. Tuft with one half-tuft impeded; E, F. Impeded tufts; G. Tuft dried without fluffing, showing half-tufts from a 37-day-old pod. Slightly less than natural size. Photographs by Marcus L. Jaeger, Division of Cotton and Other Fiber Crops and Diseases.

tuft". This division of a tuft into two parts is not evident in tufts that have dried and fluffed and can be seen best in unripe pods (fig. 1, G).

LENGTH OF FLOSS

All the tufts of a pod are not of equal length and there may be considerable variation in fiber length within a single tuft (fig. 1). Differences in fiber length can best be demonstrated by wetting tufts and fanning the fibers out on glass slides.

The longer tufts of any one pod tend to taper. Part of this tapering is due to the fact that individual fibers taper in diameter from base to tip but part is due to the fact that the fibers are not all of the same length. The difference in length between their longest and shortest fibers is not alike for all tapering tufts (fig. 1, A and B), but no attempt was made to measure the amount of fiber length variability within tufts. It would be conservative to estimate, however, that for the majority of the longer tufts, the bulk of the fibers would not be shorter than 67 to 75% of the length of the longest fibers. The longest fibers in each half-tuft of the tapering tufts may not be of the same length. In most cases, however, the difference is not greater than 2 or 3 mm and is frequently less (fig. 1, G).

There are other, somewhat shorter tufts, whose fibers appear to be all of the same length, the whole tuft having a "cut-off" appearance (fig. 1, C). There are other still shorter tufts along whose fibers, particularly near the apices, conspicuous bendings and contortions occur (fig. 1, E and F). The truncate tufts, and particularly the tufts with the bent fibers, suggest that fiber elongation has been impeded by some structural barrier. These tufts will hereafter be designated as "impeded" whereas the longer tapering tufts will be referred to as "unimpeded". Most of the impeded tufts of a pod are only a little shorter than the unimpeded ones but a few may be very much shorter (fig. 1, F).

There are some tufts only a portion of whose fibers appear to have been impeded. The fibers of only one-half tuft (fig. 1, D) or even only a portion of these may have been affected. Moreover all the impeded fibers may not be of the same length (fig. 1, F). It is possible that most tufts have some impeded fibers. Hence, the impossibility of classifying all the tufts within a pod as either impeded or unimpeded.

This deformation of certain tufts was likewise observed by Stevens (1945) who also suggests that the condition is due to crowding.

A reasonably accurate figure representing the average floss length per pod could probably best be obtained by an adaptation of the device developed by Hertel and Zerrigon (1936) for calculating the average length of cotton fibers. But to attempt to obtain a comparable figure without the aid of some such labor saving device was here shown to be impracticable.

In some preliminary studies, the possibility of using for each pod an average figure based on the length of the longest fibers in each half-tuft for 50 selected tufts was investigated and found to be reasonably satisfactory.

Statistical analysis of the data obtained showed, however, that for establishing significant differences among pods, the length of the longest fibers for the tuft as a whole was as good as the length of the longest fibers in each half-tuft. Consequently, it was decided to measure only the longest fibers for each tuft. This measurement is referred to hereafter as the "maximum floss length".

Length measurements were made as follows: A seed with its attached tuft was grasped with a pair of forceps and wetted by dipping it up and down, fibers first, into water to which a small amount of a wetting agent had been added. It was discovered that when the seed and attached tuft were pulled seed first into the water, the tuft was frequently broken off. Detached tufts are difficult to handle. The wetted tuft was then dragged by the seed through the water and onto a partially submerged microscopic slide. Three or four tufts were mounted on one slide, which was then lifted out and the excess liquid drained off. By placing a millimeter ruler behind the slide, which in turn was held against a black background, the longest fibers in each tuft were measured to the nearest millimeter. In measuring the impeded fibers, the bends and twists were not taken into consideration.

It was found that a 50-tuft sample would be sufficiently large to establish differences between pods of 2 or 3 mm in average maximum floss length as significant at the 1 percent level, the degree of precision desired (table 2). This conclusion was reached after analyzing the data representing the maximum floss length for 4 samples of 50 tufts each from 7 pods, 4 of which had a comparatively wide distribution of tuft lengths and 3 of which had a comparatively narrow one (table 3).

The following discussion on the variation in floss length among pods is based on the mean maximum floss length per pod for 150 pods, 10 for each type of Group I and 3 for 30 types of Group II, each mean being the average of 50 observations.

For the pods as a whole the average maximum floss length ranged from 18.2 mm to 50.6 mm. These figures cannot be compared with the fiber length figures that have previously been reported by Dischendorfer (1926, av. 33 mm), Gerhardt (1930, 12-30 mm), Meitzen (1862, 22-28 mm) and Neish and Burns (1921, 30-40 mm), since these investigators apparently measured individual fibers.

Stevens (1945) states that for 11 different plots of *Asclepias syriaca* growing in North Dakota the average floss length per pod ranged from 2.4 to 3.8 cms. These figures are based on the length of the majority of fibers in 5 tufts taken from each pod and would thus be somewhat smaller than length figures representing the average maximum floss length. Nevertheless, data representing the two types of measurement would be comparable in a general way. The range in length which Stevens reports is considerably smaller than that found among Michigan grown plants. This is to be expected, however, since in the study of the latter, an effort was made to include the extremes.

Type means ranged from 29.8 mm to 44.6 mm for Group I and from 28.6 mm to 49.8 mm for Group II (table 4). Some of the differences in maxi-

TABLE 2.—Results of variance analysis of data representing the maximum floss length for 4-50 tuft samples from 7 different pods, Nos. 1-4 and 5-7 having respectively wide and narrow length distributions.

Pod No.	Differences among samples within pods	
	Significant	Required for Significance at the 1% level
		mm.
1	*	1.96
2		1.73
3	**	1.98
4	**	2.08
5		.96
6	*	.81
7		.95
1-7	**	1.59
1-4	**	1.94
5-7	*	.92

* Significant at 5% level.
** Significant at 1% level.

TABLE 3.—Distribution of tufts into groups differing 1 mm in length for 4-50 tuft samples from a pod with a wide length distribution (pod 4) and one with a narrow distribution (pod 6).

Class interval	Pod 4 Sample:				Pod 6 Sample:			
	1	2	3	4	1	2	3	4
17				1				
19								
20				1				
21				1				
22								
23	1							
24			1	1				
25			1	2				
26		1						
27		1		1				
28	1	2	3	1				
29			1					
30		2	1	2				
31	1	1	1	2		1		1
32	5		1	3	1			
33	3	1	2	1	4	1	1	
34	3	1	1	7	4			1
35	3	6	4	9	6	1	1	5
36	8	8	4	8	8	5	10	8
37	10	6	9	4	12	21	19	15
38	11	12	9	2	13	15	11	11
39	3	8	7	3	2	6	6	7
40	1	1	5	1			2	2
41								

mum floss length among the types of each group were shown to be highly significant (table 5).

It is of special interest that the amount of variation within the types of Group I for either 1943 or 1944 is only slightly greater than that within the types comprising Group II (table 5). This would indicate, since each type of Group I is represented by pods from more than one plant of a clone and the majority of the types of Group II are represented by pods from only one plant, that floss length variation within a clone is not much greater than the variation within one plant. No attempt was made to ascertain the extent

TABLE 4.—Average pod and floss properties for 39 different pod types.

Group	Type Code Number	Pod[1] length	Pod[1] shape index	Maximum[1] floss length	Fiber[2] width	Fibers[2] per tuft	Tuft[1] weight	Floss[1] weight per pod	Mature[1] seeds per pod
		mm.		mm.	microns	number	mgm.	gm.	number
I	1	75.7	4.7	34.7	28.7	1640	4.274	0.8802	208
	1a	61.2	4.5	24.8	24.4	1503[3]	2.608	.4295	165
	av.	68.4	4.6	29.8			3.440	.6548	186
	2	88.3	5.9	45.5	29.5	1052	3.500	.8501	238
	2a	88.7	6.0	43.7			3.240	.7156	218
	av.	88.5	6.0	44.6			3.370	.7828	228
	3	86.3	6.9	38.2	23.9	1156	2.567	.6432	255
	3a	90.2	7.1	40.4			2.508	.6417	256
	av.	88.2	7.0	39.3			2.538	.6424	256
	4	102.1	7.0	35.1	25.4	1404	3.834	.9100	233
	4a	95.5	7.2	32.2	25.2	1322[3]	3.250	.6730	207
	av.	98.8	7.1	33.6			3.542	.7915	220
	5	99.9	8.3	34.0	24.2	1159	2.165	.5426	252
	5a	102.5	8.8	34.4		1149[3]	1.822	.5528	293
	av.	101.2	8.6	34.2			1.994	.5477	272
	6	117.6	7.0	42.5	32.3	1170	4.172	1.1338	270
	6a	113.3	7.1	44.6			3.685	.9872	268
	av.	115.4	7.0	43.6			3.928	1.0605	269
II	7	64.9	4.7	28.9	21.2	1377	2.544	.5460	214
	8	66.6	4.5	34.3					
	9	72.1	6.9	28.6			1.823	.3332	183
	10	74.6	7.9	35.8	20.3	786	1.532	.2779	181
	11	76.4	4.8	38.7			3.453	.6563	191
	12	78.8	7.3	31.1					155
	13	79.3	5.4	38.2			3.116	.7782	250
	14	79.4	4.7	36.2			3.123	.7872	252
	15	84.1	5.5	42.6			3.427	.8191	238
	16	(84.4)		(37.5)	25.8				
	17	85.9	6.6	39.8			2.755	.7322	265
	18	86.9	7.1	35.9			2.373	.6118	272
	19	87.2	5.1	43.3			3.416	.9494	277
	20	88.6	6.8	37.8			2.418	.6226	256
	21	89.3	6.4	41.4	29.2		3.467		196
	22	89.9	5.9	39.2	26.7	1600	3.918	.7704	210
	23	93.3	6.3	36.6			3.061	.7490	247
	24	93.4	5.7	38.3	28.8		2.891	.7542	261
	25	93.9	6.0	41.5	29.6	1036	3.285	.8804	276
	26	94.6	6.3	36.1			2.841	.6659	234
	27	94.7	6.3	43.8	33.9	879	2.862	.7107	248
	28	96.4	8.9	36.5			2.496	.4809	192
	29	96.9	6.6	38.5			2.734	.7241	265
	30	99.6	7.3	45.0	27.2	1018	3.263	.7955	244
	31	99.6	7.7	40.6			3.175	.7991	252
	32	103.3		39.6	26.3	1008	2.662	.6265	233
	33	103.4	8.2	35.2			2.372	.5675	239
	34			(32.5)	22.5				(187)
	35	110.2	9.5	36.9					225
	36	116.1	9.3	37.8			3.141	.6693	212
	37			(42.5)	25.4				
	38	124.7	10.8	40.7			2.953	.6077	205
	39	134.7	11.7	49.8	27.1	1194	(3.514)		258
Differences between types required for significance at 1% level				Grp. I 2.6 Grp. II 3.9	1.3	124	.446 Group I .591 Group II		

1 Means for Group I based on 5 pods for each year, or 10 pods per type; Group II, 3 pods per type, except those in parenthesis which are the average of 2 pods.

2 Means based on 2 pods.

3 Not included in variance analysis.

TABLE 5.—Analysis of variance of the average maximum floss length per pod for 150 pods representing 36 pod types and tuft weight per pod for 138 pods representing 32 pod types.

		Maximum floss length		Tuft weight	
Group	Source of variance	Degrees of freedom	Mean square	Degrees of freedom	Mean square
Group I 1943 and 1944	Types	5	352.1**	5	5.207**
	Years	1	40.4**	1	4.801**
	Types x Years	5	51.5**	5	.804**
	Error	48	4.6	48	.138
	Total	59	38.6	59	.703
Group I 1943	Types	5	110.4**	5	3.781**
	Pods within types	24	4.4	24	.169
	Total	29	22.7	29	.792
Group I 1944	Types	5	293.4**	5	2.241**
	Pods within types	24	5.2	24	.105
	Total	29	54.5	29	.473
Group II	Types	29	59.7**	25	.835**
	Pods within types	60	3.2	52	.073
	Total	89	21.9	77	.321

** Significant at 1% level.

to which the floss length, or any other floss property, varied among the individual plants of a clone.

How much of the variation encountered is due to environmental influences was not possible to estimate. The floss of the 1944 pods, taken as a whole, was very significantly longer than that of the 1943 pods (table 5). Moreover, there is seemingly a highly significant tendency for the types to behave differently in the 2 years during which the observations were made. The means show (table 4) however, that for all types except No. 1, the differences between years is not greater than 2.9 mm, which is relatively small. Type 1, however, has very much shorter floss in 1944 than in 1943, and this difference is so large that it overshadows the small differences shown by the other types. It is possible that the 1944 plants of Type 1 were not typical. It is also possible that the variation shown by Type 1 throughout the two years represents the variation that might be encountered in one year, and that if larger populations had been studied, a similar variation might have been found in all types. This is borne out somewhat by the fact that on a plant producing mainly long pods there may be found one or more short pods which appear normal in all other respects. Nevertheless, the great majority of the pods of a single plant or clone are strikingly similar in length. This observation, together with the fair degree of uniformity in floss length shown by each of 39 types either within a plant or within a clone, would warrant the conclusion that the length of its floss is an inherent property of any particular plant.

It is very obvious that long pods tend to have longer fibers than do short ones. The correlation coefficient representing the degree of relationship between maximum floss length and pod length for 150 pods is 0.546. This figure, though highly significant because of the large number of degrees of freedom, is, nevertheless, not very large. The relative size of the standard error of the estimate indicates a rather wide scatter along a regression line (4.5 mm). This scatter, however, is not a hit or miss one, but is due to the

uniformly inconsistent behavior of certain types. In other words, all the pods of one type tend to have either an average floss length-pod length relationship, or tend to have fibers longer or shorter than pods of similar length but of a different type. The differences between types and the uniformity within types is particularly well illustrated by Group I. Among the 6 types of this group there are very different floss length-pod length relationships (fig. 2), and for each type the relationship is about the same in both 1943 and 1944.

A partial explanation for differences is floss length between types whose pods were of similar length was found to lie in pod shape. To demonstrate this, it was necessary to have a figure which would represent pod "plumpness". The ratio of pod length to width (thickness) probably would have given a satisfactory figure but when it became apparent that such a figure was desirable, the pods had dried. Pod length, however, had been shown by previous observations to be very little altered in drying, and thus differences in length shown by undried pods would be shown about as well by dried ones. But plump pods may appear, after drying, little different from more slender ones. The placentas, however, did not seem to be so radically changed, and so their maximum width was used in place of pod thickness to calculate a figure to represent pod plumpness. This figure will be referred to as the "pod shape" index and is obtained by dividing the pod length by the placental width. This index can be used only for comparing pods of similar length. The plumper they are, the smaller will be the pod shape index.

For 35 types, and considering separately the 1943 and 1944 pods of the Group I types, the average maximum floss length was plotted against the average pod length (disregarding the fact that the means are not based on equal numbers of observations). The average pod shape index was used to indicate the plotted points (fig. 3). Within any length group there is a ten-

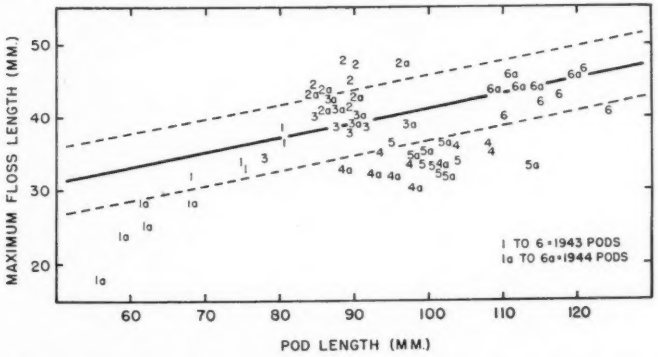

Fig. 2. Regression of maximum floss length on pod length for 150 pods, plotting only the 60 pods of Group I (5 for each of 2 years for 6 types from 1 locality). Each plotted point is indicated by the type code number and represents the mean of 50 observations for maximum floss length and 1 observation for pod length. Regression equation: $E = 0.2X + 21.3$; *S. E. E.* = 4.5 mm; $r = 0.546$.

dency for the slender pods to have the shortest floss and the plump pods to have the longest. There are exceptions, however. The absence of a more distinct trend may indicate that there are types whose floss length cannot be explained by pod length and pod shape alone. Some of the inconsistencies may result from an insufficient number of observations and to the lack of a more precise way of representing pod shape.

No extensive investigations were made of the extent to which types might differ in the amount of tuft length variation within pods. In accumulating the data for calculating the average maximum floss length, however, certain types were definitely shown to be consistently less variable than others in this respect (table 3). A very large part of the variation in tuft length within pods is due to the occurrence of impeded tufts. Some of the latter are undoubtedly produced, in part at least, by obstructions to elongation caused by the curvature of the fruit wall. From this it might be concluded that plump pods would have more impeded tufts and, therefore, more tuft length variation than slender or gradually tapering ones. But the differences between types in the amount of tuft length variation within pods could not be consistently related to pod length or to pod shape differences.

And finally there were certain types which appeared to differ in the extent to which fiber length varies within tufts. But no way was developed for measuring this variability and consequently no dependable observations were made.

It was not to be expected that the external features of the pods, that is its smoothness or spininess would have any direct bearing on floss length. It was not inconceivable, however, that smooth pods, which appear to have thinner shells than ridged or spiny ones, might have some common floss length property, as might also the ridged and spiny types. None was observed, however.

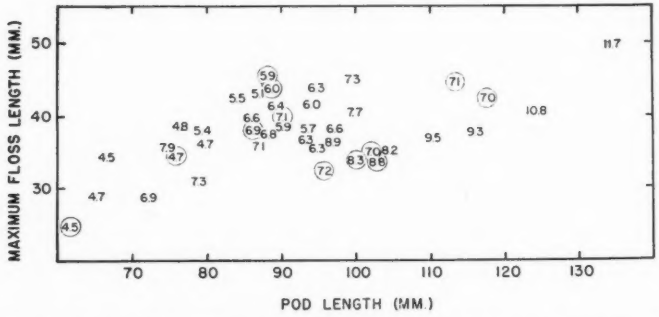

Fig. 3. Scatter diagram showing the relationship between the average maximum floss length and pod length for 35 pod types, the 1943 and 1944 lots for the 6 types of Group I being considered separately. Each plotted point is indicated by the average pod shape index and represents the average of 5 pods for the types of Group I and 3 pods for the types of Group II. Group I = encircled figures.

All of these observations on floss length differences among pods indicate that although floss length is determined to a considerable extent by pod length and pod shape, very probably there are types among the different forms of *Asclepias syriaca* which possess floss length characteristics that are not related to pod length or to pod shape but which are nevertheless very definite and inherent characteristics of the type.

FIBER WIDTH

The dry milkweed fiber is a slightly flattened tube that tapers from base to tip. Dischendorfer (1926) describes the fiber shape as that of a trapezium. He also suggests that the diameter decreases slowly at the base and more rapidly at the tip. The present studies, in which individual fibers were measured at 1 mm intervals throughout their lengths, indicate that the taper is fairly regular except, for at least the longer fibers, for 2 or 3 mm at the tip and 3 or 4 mm at the base, at which places decrease in width is more rapid than throughout most of the fiber length (fig. 4).

Since the mature, dried milkweed fiber is not isodiametric, the measure of the width of the fiber as seen in longitudinal view under the microscope is not a measure of a true diameter but probably the measure of what would be the length of the major axis in a cross-sectional view of the fiber. The measurement will be referred to, however, as "fiber width". There may be some question as to the value of such a measurement since it is not certain that the major axis would always be measured. Moreover, it is possible that the degree of collapse may not be the same throughout the length of a fiber and

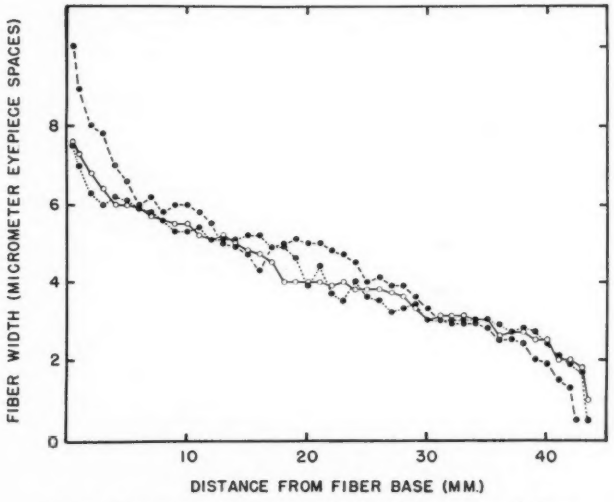

Fig. 4. Fiber width at 1 mm intervals from base to tip for 3 fibers.

may not be comparable for all fibers. Nevertheless, it was decided to measure fiber width for a limited number of pods to ascertain whether, in spite of the possibility of encountering a large amount of width variability, there occurred fiber width differences among types that could be demonstrated by a reasonable number of observations.

Preliminary measurements indicated that differences in mean fiber width could be satisfactorily demonstrated at any position along the lower half of the fiber length. After taking into account such matters as the relative size of the personal error and the ease of handling the material, it was decided to make the measurements at a distance of 10 millimeters from the fiber bases.

Some idea as to the extent to which fiber width might vary within a single tuft was obtained after attempting to measure all the fibers within one half-tuft of one seed from each of 3 pods. Small groups of fibers were separated from the half-tuft and measured, starting at the outermost edge of the tuft as a whole, and progressing across the half-tuft, measuring last those fibers that were adjacent to the other half-tuft. Because of the tendency of the tuft to fragment, an entirely orderly progression of sampling could not be accomplished. It is estimated that only about one-half of the fibers of each half-tuft were measured. Some were lost in making the mounts and within each mount some fibers always overlap so that their edges are not sufficiently distinct to allow accurate measurements to be made.

The recorded data were divided into samples of 25 fibers each, starting with the first measured fiber at the outside of the tuft.

Considerable variation in the average fiber width was found among the samples of each half-tuft (table 6). There is a progressive increase in width from the outside inwardly, with some tendency for a decrease in width for those fibers that are adjacent to the other half-tuft.[3] That the sample means

TABLE 6.—The average fiber width (in eyepiece micrometer spaces*) for samples of 25 fibers each selected progressively across each of 3 different half-tufts, starting at the extreme outer edge (sample 1).

Sample No.	Tuft 1	Tuft 2	Tuft 3
1	5.660	5.016	5.528
2	6.060	4.860	5.428
3	6.460	5.064	5.644
4	6.180	6.116	6.152
5	5.956	5.596	5.848
6	6.328	6.100	5.856
7	6.148	5.992	6.004
8	7.006	6.012	6.024
9	6.168	5.976	6.036
10		5.884	6.244
11		5.272	6.200
12			6.076
13			6.316
14			6.308
av.	6.2184	5.6262	5.976

* One eyepiece micrometer space = 4.762μ.

3 Observations on young seeds have shown that the peripheral fibers are the youngest and in unimpeded tufts are also the shortest.

do not show a more precise progressive increase in fiber width may be due to the fact, as was stated previously, that the sample sequence is not exact.

From these data it is evident, even without statistical analysis, that a 25-fiber sample is not sufficiently large to represent adequately a single half-tuft. A sample taken from somewhere near the center of the half-tuft would, however, seem to be fairly representative of the majority of the fibers if the outermost ones are excluded. Without making further analysis at this time, it was decided that a type should be represented by 2 pods, 25 fibers to be measured for each of 10 seeds from each pod. A pod mean would thus be based on 250 observations and a type mean on 500, numbers which if not being small are not unreasonably large. This size of sample was later shown to be sufficiently large to establish differences between types of 1.28 microns in mean fiber width as significant at the 1 percent level (table 7). This difference is about 4.8 percent of the mean for all types studied and is considered a satis-

TABLE 7.—Analysis of variance of the average fiber width for 10 seeds from each of 42 pods representing 19 pod types[1] and for the number of fibers per tuft for 3 tufts from each of 38 pods representing 14 pod types.

Source of variance	Fiber width[2]		Number of fibers per tuft	
	Degrees of freedom	Mean square	Degrees of freedom	Mean square
Types (lots)	20	10.09**	13	376,977**
Pods within types	21	.86**	14	17,356**
Error	378	.11	56	6,387
Totals	419	.62	83	66,282

** Significant at the 1% level.

1 Though 19 types are represented, there are actually 21 lots of 2 pods each, types 1 and 4 each being represented by 2 lots, one for 1943 and one for 1944.

2 Analysis based on micrometer eyepiece spaces, each of which = 4.672μ.

factory figure. It must be emphasized, however, that the fiber width variability used in arriving at this "least difference significant" is the variability among seed means, not among individual fibers.

The fiber samples were taken from unimpeded tufts. The fibers were mounted in mineral oil and the measurements were made with an eyepiece micrometer. The analysis of the data was made without converting the readings to microns.

Fiber width measurements were carried out on 19 types, representing extreme and average conditions of floss length and of pod length, shape and surface characteristics.

At a distance of 10 mm from the base of the tuft, the average fiber width per pod for 42 pods ranged from 20.1308 microns to 33.6920 microns. These figures cannot be compared with those reported by other investigators because among the latter there is lack of uniformity or of information regarding the position at which the measurements were made. A width of 0.02 to .05 mm (20 to 50 microns) is reported by Gerhardt (1930) and Mietzen (1862) gives the fiber breadth as being from 14 to 33 microns (Dischendorfer, 1926) but neither states at what place along the fiber length the measurements were

made. Dischendorfer (1926) states that the breadth is 31 to 33 microns at the base and 5 to 7 microns at the tip.

The data representing the average fiber width for 420 seeds (2 pods x 10 seeds x 21 lots) were subjected to variance analysis. Actually data from only 19 types were analyzed, but types 1 and 4 are represented by 4 pods each, 2 for 1943 and 2 for 1944, making 21 lots of 2 pods each. Type differences, in general, however, would correspond to lot differences.

Statistically significant differences in fiber width were shown to exist among the 21 types (lots) as well as between pods within types (lots) (table 7). This information, though of interest, means little by itself. When fiber width differences are considered in relation to floss length differences, however, there is found to be a highly significant tendency for fiber width to increase with increases in floss length for the pods taken as a whole ($r = 0.623$), for types (lots) ($r = .625$), and also for pods within types (lots) ($r = .607$) (fig. 5). Thus, the significant differences in fiber width that were shown to exist among the pods of a type (table 7) can, in some measure, be explained by differences in floss length.

The scatter along a line representing, for all the pods, the regression of fiber width on floss length is rather broad (*S.E.* = 2.76 microns) but, in general, the relative positions with regard to the regression line are about the same for the pods representing a type (fig. 5). This would indicate that there do exist among the different pod types, inherent differences in fiber width that are not directly related to fiber length. The existence of such type differences is further substantiated by the fact that the type means, after adjusting for differences in floss length, still show highly significant differences.

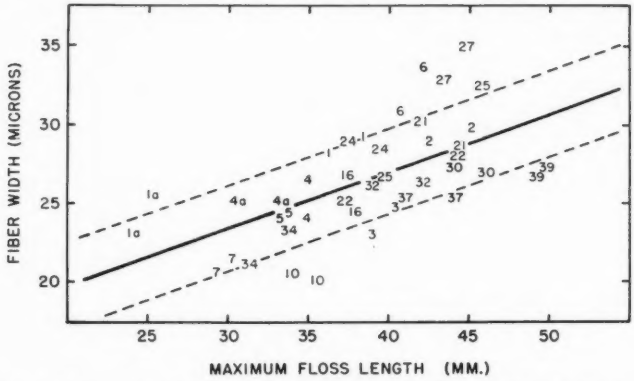

Fig. 5. Regression of fiber width on maximum floss length for 42 pods representing 19 pod types: 2 pods for each of 17 types and 2 for each of the 1943 and 1944 pods of types 1 and 4. Each plotted point is indicated by the type code number and represents the mean of 250 observations for fiber width and 50 observations for maximum floss length. Regression equation: $E = 0.3619X + 12.5983$; *S. E. E.* $= 2.7639\mu$; $r = 0.623$.

No consistent relationships for these differences were etablished. There is, however, a not too well defined tendency among types having similar length for a large fiber width to accompany a large number of fibers per tuft and vice versa. There are exceptions, however, and so it is possible that these relationships are specific for these particular cases and do not indicate any definite trend.

As would be expected from the two-fold relationship of floss length to fiber width and to pod length and shape, there is a general tendency for long pods to have wider fibers than short ones and plump pods wider fibers than slender pods of similar length. Differences in fiber width were not found to be consistently related to differences in the external features of the pod, that is, its smoothness or spininess.

NUMBER OF FIBERS PER TUFT

Some clue as to the existence of extreme differences in the number of fibers per tuft usually can be gathered from the general appearance of the tuft as well as from the floss length-tuft weight relationship. Fiber counts per tuft were made only for those types suspected of having either an extra large or extra small number of fibers per tuft and for some that appeared average in this respect. In all, only 14 types were examined.

A tuft whose fibers were to be counted was first wetted and then cut into two parts about 15 to 18 mm from the base. The basal part was stained in a safranin solution until a deep color had been acquired and then washed. Using a wide field microscope and with the aid of dissecting needles, the cut ends of successive small groups of fibers (5, 6, or 7) were pulled to one side from the main clump and counted, starting at the right. All the fibers in a tuft were counted. During this manipulation, the seed usually becomes detached, but the loss of the seed offers no difficulty in the handling of the tuft.

Three tufts were considered the sample for 1 pod. This size of sample undoubtedly does not give an adequate picture of the variability within the pod and yet it was sufficiently large to indicate striking differences among types. Two pods were examined for each type.

For the majority of the pods examined the number of fibers per tuft ranged from about 1000 to 1300. Those types with strikingly larger tufts bore about 1300 to 1800 fibers per seed whereas those with smaller tufts bore from about 700 to 1000 (table 4).

Dischendorfer (1926) is the only investigator reporting on the fiber number per tuft for *Asclepias syriaca*. He found in European grown material that the number varied from 680 to 996, with an average of 910 fibers for 10 tufts.

When the data representing the number of fibers per tuft for 84 tufts (14 types x 2 pods x 3 tufts) were subjected to variance analysis, highly significant differences among pod types in the number of fibers per tuft were established (table 7).

For 3 of the types of Group I (Nos. 1, 4, and 5) the average number of fibers per tuft was determined for both 1943 and 1944 pods. The results are not entirely consistent and yet, in general, the tendencies shown by the 3 types in 1943 are shown also in 1944 (table 4).

Differences in tuft size were not found to be consistently related to differences in pod size, shape, or surface ornamentations. Among types having similar floss length, there is some slight tendency for the fibers of the larger tufts to be wider than those of smaller tufts. But as was pointed out earlier, these particular cases may not indicate general trends, for there are exceptions.

TUFT WEIGHT

The tuft weight per pod was obtained from the weight of 100 tufts. The tufts comprising the weight sample were detached from their seeds and placed in a glass vial whose weight was known. The vial plus the floss was weighed, the floss weight calculated and the tuft weight expressed in milligrams. The weights were carried out to .0001 gr., the limit of the balance used.

The weight studies covered a period of about 14 months. There were no constant temperature and humidity chambers available and so the problem of fluctuations in floss weight with changes in atmospheric conditions was met by the use of check samples. From the first lot of samples weighed, 5 were selected to be the checks. They were weighed along with every succeeding lot of samples. The average percentage gain or loss of the checks for an arbitrarily selected "Correction Day" (Feb. 23, 1944) as compared with their weight on the test day, was used to correct the weight of the current samples.

After several lots had been weighed, it became evident that a correction factor probably was not necessary. In no case did a check sample gain or lose more than 1.004 percent of its total weight. Usually the percentage gained or lost for any sample on any day was much smaller, in the majority of cases being under 0.8 percent. Such small fluctuations could probably have been disregarded, nevertheless, the weight of each sample was corrected to that of the "Correction Day".

The weight per tuft ascertained for 138 pods ranged from 1.371 to 5.108 mgm. Dischendorfer (1926) found tuft weight to average from 2.0 to 2.7 mgm. The maximum figure he reports, 2.7 mgm, is not far from the average that was found for the total of 138 pods, namely, 2.996 mgm. Meitzen (1862) reports a weight of 1/20 of a grain, or about 3.24 mgm, which is within the range found in the present studies.

For the types of Group I the average tuft weight ranges from 1.994 to 3.928 mgm, and for those of Group II from 1.532 to 3.918 mgm. In each group and in each year there were shown to be statistically significant differences in tuft weight among types (table 5).

Differences in tuft weight among pods or among pod types can probably be attributed largely to differences in such floss properties as floss length, fiber length variability within the tufts and among the tufts of the same pod, fiber width, number of fibers per tuft and possibly the thickness of the fiber wall.

The factor of tuft length was first investigated. Scatter diagrams showed the expected tendency for floss weight per tuft to increase with increases in floss length. The correlation coefficient representing the degree of relation-

ship between tuft weight and maximum floss length is small (0.458), but because of the large number of degrees of freedom it can be considered highly significant. The standard error of the estimate is relatively large (0.630 mgm) indicating a wide scatter along the regression line. However, all of the pods of one type fall in about the same relative position with regard to the regression of tuft weight on floss length (fig. 6). This fact, together with the wide scatter, would indicate that there are distinct differences among types that cannot be explained on the basis of differences in maximum floss length. The existence of such consistent differences is illustrated particularly well by Group I. Among the 6 types of this group, there are striking differences in tuft weight-floss length relationships (fig. 6). Moreover, the differences shown between types in 1943 are shown to about the same degree in 1944 (fig. 6, table 5). No covariance analysis of the data was undertaken for the behavior of the types seemed to be adequately shown by the scatter along the regression line.

Some of the striking differences in tuft weight among pods having about the same floss length may be explained by differences in the number of fibers per tuft, by the fiber width, or by the combined effect of the two properties.

In Group I (fig. 6) Type 1 for 1943, Type 4 and Type 5 have about the same floss length. Types 1 and 4 have much heavier tufts than Type 5 and tend to have not only more fibers per tuft, but also wider fibers (table 4).

In Group II (chart not shown) the explanation for the very light tuft weight of type 10 may be found in the comparatively small number of fibers per tuft (table 4) and the relatively narrow fiber width. The heavy tufts of No. 22 must be attributed mainly to a large number of fibers per tuft,

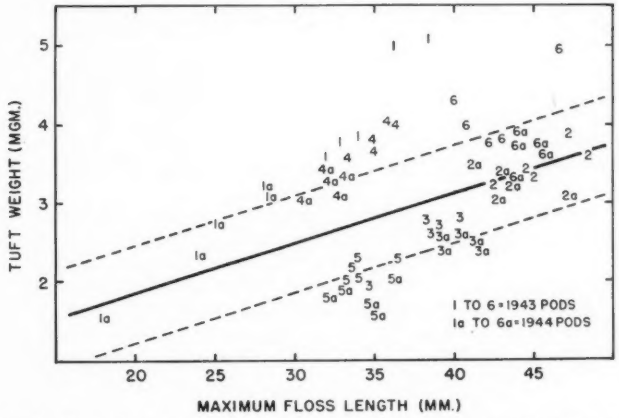

Fig. 6. Regression of tuft weight on maximum floss length for 138 pods, plotting only the 60 pods of Group I (5 for each of 2 years for 6 types from 1 locality). Each plotted point is indicated by the type code number and represents 1 observation for tuft weight and the mean of 50 observations for maximum floss length. Regression equation: $E = 0.063X + 0.601$; *S. E. E.* = 0.630 mgm; $r = 0.458$.

for the fiber width is about what would be expected from its floss length (fig. 5). Type 7 has about an average tuft weight-floss length relationship, yet has a comparatively large number of fibers per tuft. The large tuft, however, is compensated for by a relatively narrow fiber width, and this probably accounts for the average tuft weight.

There is considerable variation within types and among types for which no satisfactory explanation was found. In general, differences in floss length within types must be rather large for there to be a corresponding difference in tuft weight (fig. 6). Moreover, the significantly heavier floss of the 1943 pods of Group I as compared with those of 1944, cannot consistently be explained on the basis of floss length differences (table 4). What fiber property other than length may have responded to environmental influences in such a way as to bring about differences between years was not determined.

The extent to which differences in tuft weight among pods could be explained by differences in fiber length variation within pods or within tufts, or by possible differences in fiber wall thickness were not investigated.

Tuft weight by itself is of little value when the total yield of floss per pod is being considered, because pods vary considerably in the number of seeds they possess.

Any attempt to relate the number of seeds per pod to pod shape or length did not prove to be very satisfactory. This is due, in part at least, to the fact that in such a study, variations in seed size would also have to be taken into consideration. Seed size is not being considered here in detail, though it should be stated that certain types differ very markedly in the size and shape of their seeds.

For all but a few pods, for which the complete data were not available, the yield of floss per pod was calculated by multiplying the weight per tuft by the number of matured seeds per pod. The mean for each type was then obtained, considering separately the 1943 and the 1944 pods of Group I. The average floss weight per pod for the 30 types ranged from about 0.28 gr to about 1.13 gr. These means were plotted against the average pod length, using the average pod shape index to indicate the floss weight—pod length relationships (fig. 7). There was found to be a general tendency for floss weight per pod to increase with pod length, but the scatter is rather wide. There is also a very marked tendency for the slender pods to have less floss by weight per pod than plump pods of similar length. Stevens (1945) likewise finds a tendency for floss weight per pod to increase with pod circumference, but is of the opinion that differences in pod length are of little importance.

It is obvious that to explain difference in floss weight per pod among types, various factors must be taken into consideration. The low yield of Types 5, 9, 10, 28, 33, 36, and 38 and the high yield of Types 1, 6, and 19 (Table 4, fig. 7) in all cases cannot be explained only by the fact that, as has been pointed out earlier, slender pods tend to have shorter floss and, therefore, lighter tufts than do plump pods of similar length. Differences in the number of seeds per pod may be a partial explanation for yield differences in certain cases while tuft weight variations due to differences in fiber number per tuft, or in fiber width may be partial explanations in certain other cases. For example, the fact that the floss is very short in relation to the pod length

seems to be the chief explanation for the low yield of Type 5, for it has a rather large number of seeds per pod (average 272), but an average number of fibers per tuft and average fiber width. Type 10 has low yield but an average pod length-floss length relationship. Its low yield can be explained by the fact that it has few seeds per pod (181) and few relatively narrow fibers per tuft.

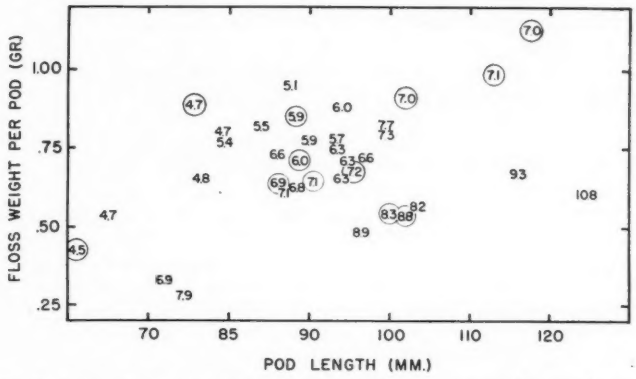

Fig. 7. Scatter diagram showing the relationship between average floss weight per pod and pod length for 30 pod types, the 1943 and 1944 lots for the 6 types of Group I being considered separately. Each plotted point is indicated by the average pod shape index and represents the average of 5 pods for the types of Group I and 3 pods for the types of Group II. Group I = encircled figures.

Types 1 (1943) and 6 have about an average floss length-pod length relationship, but their high yield can be attributed to a large number of fibers per tuft, and also in the case of Type 6, to a large number of seeds per pod (269). Type 19 tends to have floss that is rather long for its pod length and the effect of this property on tuft weight together with the fairly large number of seeds per pod (277) would explain its high yield.

Conclusions

The foregoing observations made on plants of *Asclepias syriaca* growing in Michigan, show that plants differing in the size, shape and external features of their pods may also differ in such floss properties as length, fiber width, number of fibers per tuft and floss weight per tuft and per pod. There is a certain amount of relationship among the fiber properties as well as between fiber and pod properties. However, pod types may possess inherent floss and pod characteristics for which no consistent relationships were found.

Pod length and shape can foretell probable floss differences or similarites within limits. Differences in pod length usually indicate corresponding differences in floss length, but the plumpness of the pod has some influence on the length of its floss and, therefore, pod shape has to be taken into consideration in predicting floss length. Even then, a selected type might be one

whose floss length-pod shape relationships were not in alignment with those of the majority of the pods. The surface characteristics of a pod, its smoothness or its spininess were not found to be consistently related to any of the floss properties studied.

Known differences in one fiber property can in some cases predict differences in other fiber properties. In general, a longer floss would mean wider fibers and a heavier tuft provided there is no great difference in the numbers of fibers per tuft. But exceptions do occur. The number of fibers per tuft may possibly have some positive relationship with fiber width, but on the whole, pods whose tufts have an exceptionally small or large number of fibers possess no consistently distinguishing floss or pod characteristics. Type differences or similarities in tuft weight or floss weight per pod admit of no one explanation. These two properties are not simple ones but the result of the interaction of several floss and pod properties, variations in one or more of which may be the explanation for tuft or floss weight in one case, variations in others being the explanation in another case.

If it should be desired to select types possessing specific floss characteristics or combinations of characteristics, it would be necessary to examine pods from different clones until the desired types were found. In general, however, if a high yield per pod is desired, plants bearing large plump pods presumably would be satisfactory. Moreover, it is very probable that such a plant would produce comparatively long floss and comparatively wide fibers.

Summary

A study was undertaken to ascertain whether or not there are distinct differences in floss properties among certain different pod types of *Asclepias syriaca* in Michigan. It was also desirable to know, in the event of a future propagation of the plant for the commercial production of its floss, the extent to which these floss properties are interrelated and the extent, if any, that they are related to certain general kinds of pods.

One hundred and fifty-six pods representing 39 different pod types were studied in detail.

Techniques and procedures were developed for determining on a pod basis the (1) maximum floss length, (2) fiber width, (3) number of fibers per tuft, (4) tuft weight and (5) floss weight per pod.

Some of the differences in length of floss, width of fiber, number of fibers per tuft and tuft weight among the 39 different pod types were shown to be statistically significant.

In general, floss length was found to increase with increases in pod length, but there was a tendency for plump pods to have longer fibers than slender pods of similar length. There are also distinct and apparently inherent differences in floss length among types that are not associated with differences in pod shape, size, or external features.

Fiber width tends to increase with an increase in floss length. Therefore, long pods tend to have wider fibers than short pods and plump pods wider fibers than slender ones of similar length. There are differences among types, however, that cannot be explained by pod differences in shape or length or by differences in floss length. There is a very slight and perhaps questionable

tendency for tufts with a large number of fibers per tuft to have wider fibers than those with a small number but of similar floss length. Fiber width differences were not found to be consistently related to differences in the external features of the pods.

The number of fibers per tuft for most of the types ranged from about 1000 to 1300. But certain types had significantly larger or smaller tufts. Aside from the possible relationship of fiber number to fiber width as stated above and the very obvious influence of tuft size on tuft weight, the number of fibers per tuft was not found to be consistently related to any of the other pod and floss properties being considered.

There were significant differences among types in floss weight per tuft. Variations in this property can be attributed in part to differences in floss length, number of fibers per tuft, and to fiber width.

The floss weight per pod is determined by the number of seeds per pod and the tuft weight. Since both of these factors are exceedingly variable, and since tuft weight itself is influenced by several different factors each of which may vary among types, differences in yield among types cannot always be explained by variations in the same properties or set of properties. In general, however, plump pods tend to yield more floss by weight than slender pods of similar length, since the plumper pods would tend to have longer and, therefore, heavier tufts.

It may be concluded, that, though there are inherent floss characteristics for which no relationships could be established, certain general characteristics of the floss can be predicted from the length and shape of the pod and if only one fiber property is known. In general, high yield per pod would undoubtedly be assured by the selection of plants with large plump pods, and such a type would probably possess comparatively long and wide fibers.

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Texas Plant Collectors as Represented in Texas Herbaria

Fred A. Barkley

A list of plant collectors of any area is of historical interest; but the custom among plant monographers of citing each plant specimen by its collector and collecion number[1] makes it especially desirable to have available lists of such collectors. There has never been such a list prepared for Texas and with the increased interest in the Texas flora, such a list seems desirable. Many herbarium specimens carry only a surname or initials and often the full name can be obtained, if at all, only by the chance encounter of one sheet carrying the full name among many which do not.

The author began this tabulation in the University of Texas Herbarium to obtain as complete a list of collector's names and years of their collecting as possible for that herbarium. The herbarium was arbitrarily divided into nine approximtaely equal parts, the sheets in each fifth pigeon-hole[2] being listed as to collectors[3] and their dates of collection. Since it was desirable also to know the approximate number of specimens from Texas in the herbarium, the number of Texas plants of each collector was counted.[4] The proportionate effectiveness of sampling may be judged from reference to Table 1, which gives a portion of the tabulation from the nine portions of the herbarium and the total in the herbarium for each collector. The total tabulation for the University of Texas Herbarium is given in Table 2, column 7 *(Tx1)*.

Having completed the tabulation for the University of Texas Herbarium it was decided that similar counts for other Texas herbaria would be interesting for comparison. These counts were made. They cover the mounted herbarium sheets of Texas plants having definite collector's data in the herbaria until the end of 1944.[5] Reference to Table 2 will show the counts.[6] In all cases

1 Unfortunately many collectors in our area have neglected collection numbers so that their specimens have to be cited by dates. Too many (see Table 2) have not given dates of collections.

2 Thus by multiplying by five one would obtain the approximate number of specimens of Texas plants in the herbarium.

3 Of Texas plants only.

4 Where joint collections were found, each collector was assigned the proportionate credit, and at the end of the tabulation the number was raised to the next whole number.

5 Sheets without any reference to a collector or ascribed to a class, organization or institution, were not tabulated. No out-of-state collections nor unmounted herbarium material was included.

6 See explanation of Table 2.

TABLE 1

A portion of the count of herbarium specimens by collectors in the University of Texas Herbarium. The specimens from each fifth pigeon hole were tabulated for nine arbitrarily selected portions of the herbarium. [Notwithstanding special tastes shown by collectors for certain groups, from the general correspondence over the herbarium in the counts, it was decided that this was adequate sampling.]

1937-1938	Akin, Berta	6									6
	Albrecht, Olin									1	1
1914-1920	Allen, Ena Alida				6	3	4	6	6	3	28
1930	Apeliner, Conrad					1					1
1927-1929	Armer, Annie	2	1	5	7	14	3	8	14	9	68
	Babs, LeRoy					1					1
	Bailey, Effie					1			1		2
1917	Bailey, E. A.						1				1
1901	Bailey, V.							1			1
1931	Baker, Bryant O.		1			3		3	3	5	15
1931	Barber, Lucille J.				1						1
1929	Barker, Paul						3			1	4
1943	Barkley, Fred A.		2					1			3
1932	Barkley, LeRoy						1				1
1928-1933	Barrow, Louise								3	2	5
1905	Bartlett, H. H.							7			7
	Bates, Leroy						1				1
	Beasley, Mary Alice							2			2
1900	Beck, Mary Anne								1	1	2
1930	Beckman, Thelma								2		2
1930-1932	Beede, Francis				2	1			2		5
1929	Bedingfield, Opal						2				2
1932-1933	Benedict, Dolores						1	1			2
1932	Bengel, Elaine						1				1
1932	Bengel, Margaret						2				2
	Bennett, Ralph W.				1		1				2
1921-1925	Berkman, A. H.	5	4		3	3	6	10	12	7	50
1935	Beth, Nora						1				1
1939	Bibby,							2			2
	Birge, Juanita				2						2
1909-1910	Birge, Willie Isabella		1				1	1	1		4
1928	Black, H.							1			1
	Blackburn, J.									1	1
1939	Blackwell, Carrie								1		1
1926-1928	Bogusch, E. R.	2	10	3	11	31	11	26	44	28	166
1932	Bone, Genevieve							1			1
1931-1933	Booker, Josephine					8	3	1	2	3	17
1930-1936	Boon, Effie	17	1	4		50	12	27	30	11	152
1931	Boring, Ruth								1		1
1938-1939	Brackett, Eunice		4			13	12	9	15	18	71
1930	Brandt, Gertrude									2	2
1897-1904	Bray, W. L.	8	6		1	30	26	37	31	38	177
1910	Breuer, Miles J.					1	3	1			5
1934	Brewer, R. C.									4	4
1937	Bright, John						2				2
1932	Brillhart, Elmer									1	1

one pigeon-hole out of five was tabulated.[7] The Eula Whitehouse, Effiie Boon, Mr. & Mrs. L. Irby Davis,[8] Elsie McElroy Slater,[9] Mrs. Jerry E. (Norma) Stillwell, and Richard W. Pohl herbaria are not included because the author could not visit them and since exact tabulations were not furnished. George L. Fisher's American Botanical Exchange Collection in Houston, which was visited, is not listed since it is maintained for exchange purposes only and is entirely unmounted.[10]

Having completed the tabulation in as far as possible for Texas herbaria, it was decided for comparison to tabulate the collectors in the available portions of the monographs in C. L. Lundell's Flora of Texas.[11] Most of these represent study not only of extensive material in Texas herbaria, but also of Tejan specimens in most of the larger herbaria of the United States, and, in some cases of foreign countries. (This count is given in Table 2, column 4 (*TF1*).)

Since the total number of Texas specimens in the Chicago Natural History (Field) Museum Herbarium was easily available it is given (Table 2, column 1 (*TCh*)) for comparison of an out of state herbarium with those in Texas. This represents the Tejan specimens in that herbarium through 1944.

The number of collectors' names represented in the list from Flora of Texas not included in the list from Texas herbaria, raised the question of

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7 The author made the tabulations except in the case of the following: Herbarium of Texas Technological College, the Bogusch and Sinclair Collections at the Texas College of Arts and Industries, John Tarleton Agricultural College Herbarium, Mary Hardin-Baylor College Herbarium (counts through the courtesy of W. W. Barkley), Baylor University Herbarium (count through the courtesy of Martha Thurlow), Robert Runyon Herbarium (count through the courtesy of Robert Runyon), L. C. Hinckley Herbarium (count through the courtesy of L. C. Hinckley), and the Soil Conservation Service Herbarium (count through the courtesy of Charles J. Whitfield).

8 The Davis collection contains collections of both Mr. and Mrs. L. Irby Davis.

9 The Elsie McElroy Slater Herbarium contains Texas collections of Elsie McElroy Slater, Mrs. Royal Jackman, Mary Elizabeth Harper, Eula Whitehouse, Ellen Quillen, and Emma Eynon.

10 In many private herbaria the counts do not represent anything like the complete collection, where many plants are often left (unmounted) in folders for use. In the larger herbaria where the volume of material going into the herbarium is great, the work of poisoning and mounting being time consuming, the material is often from one to five years in getting into the herbaria after being received. It may be well at this place to point out that since only Texas collections are tabulated, the totals do not indicate the comparative size of the herbaria, since some herbaria contain Texas material only, while others have several times as much out-of-state material as of Texas material. It would be unwise to judge the potential value of collections by size alone. Many things are involved which must be considered in evaluating specimens: period of collection, where collected, completeness of data, adequacy of specimen, method of poisoning, and adequacy of pressing and mounting.

11 MOLDENKE, H. N. 1942—ERIOCAULACEAE, AVICENNIACEAE, VERBENACEAE. **3**:1-87; BARKLEY, F. A. 1943—ANACARDIACEAE. **3**:89-108; LUNDELL, C. L. 1943—CYRILLACEAE, AQUIFOLIACEAE. **3**:109-122; YOUNCKER, T. G. 1943—CONVOLVULACEAE:CUSCUTA. **3**:123-150; CORRELL, D. S. 1944—ORCHIDACEAE. **3**:151-196; BAILEY, L. H. 1944—PALMACEAE. **3**:197-199; SMITH, L. B. 1944—BROMELIACEAE. **3**: 200-207; MUNZ, P. A. 1944—ONAGRACEAE. **3**:208-262.

where these collector's specimens are deposited. In order to get some indication of this, several monographs[12] were tabulated[13] as far as Texas specimens were concerned. (This tabulation is given in Table 2, column "'45 to 93".) The herbaria from which specimens are studied and cited by monographers of course vary with the conditions under which the monograph is prepared and therefore may only give rough indication of location of available Tejan specimens.

The compilation of this list has indeed been a pleasure since in the course of its preparation the author has had the opportunity to meet either personally or through correspondence most of the botanists of Texas who are interested in plant taxonomy. He has been met throughout with courtesy and enthusiasm. The author is indebted to Mr. W. W. Barkley and Dr. B. C. Tharp for material assistance in visiting several of the herbaria, to them and to Mr. Paul C. Standley, Dr. Eula Whitehouse, Dr. Lloyd Shinners, and Dr. S. W. Geiser for helpful suggestions concerning this study, and to Willya Barkley, for assistance in the preparation of tables and with the proof.

Such a list of necessity shows many gaps. It is hoped that others interested will be able to fill many of these. Information on herbarium labels is sometimes erroneous, so that it may have been carried into the tabulations. Several such cases have been found and corrected. The author will be grateful for any additions or corrections which anyone has to make in this list, for it is only by bringing together such fragments of widely scattered information that a list such as this can approach completeness. It is to be hoped that such knowledge may be brought together before it is lost, since much information concerning early plant collectors has already been irretrievably lost.

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12 ENGLER, A. 1883—ANACARDIACEAE. A. & C. De Candolle's Monographiae Phanerogamarum **4**:171-500; KEARNEY, T. H. 1935—North American species of *Sphaeralcea*. Univ. Calif. Publ. Bot. **19**:1-128; PENNELL, FRANCIS W. 1928—*Agalinis* and allies in North America I. Proc. Phila. Acad. Sci. **80**:339-449; MUNZ, P. A. 1938—Studies in the ONAGRACEAE XI: A revision of the genus *Gaura*. Bull Torr. Bot. Club **65**:105-122, 211-228; BRACKETT, A. 1923—Revision of the American species of *Hypoxis*. Rhodora **25**:120-147; PENNELL, F. W. 1935—SCROPHULARIACEAE of eastern temperate Norfth America. Phila. Acad. Nat. Sci. Monogr. **1**:1-650; BARKLEY, F. A. 1937—A monographic study of *Rhus* and its imemdiate allies in North and Central America, including the West Indies. Ann. Mo. Bot. Gard. **24**: 265-498; BARKLEY, F. A. 1940—*Schmaltzia*. Amer. Midl. Nat. **24**:647-665.

13 In this list herbaria are starred where a collector was listed as having made important Texas collections and where large sets of that collector are listed as being deposited in a herbarium, in the very useful reference: Pennell, F. W. Reference list of collectors in the Schrophulariaceae of Eastern North America. *Phila. Acad. Sci. Monogr.* **1**:597-624. 1935. Discrepancies between the counts given and the important collections as there given will be noted. Important among the reasons for this are: the present tabulation from monographs is not exhaustive; recent changes in important collections through bequest, exchange, and otherwise; collectors specialization in groups which were not sampled in the monographs selected; and the scattered selection of herbaria by the monographers for their studies. Pennell's list indicated important sets of the collectors and his list includes all collections in the United States while those listed as having important collections for Texas are the only ones included in the present list.

EXPLANATION OF TABLE 2

A list of 1369 Texas plant collectors and inclusive years of collecting in Texas as assembled from various sources. A name in the list preceded by an asterisk (*) indicates the person is listed in "A Partial List of Naturalists and Collectors in Texas, 1820-1880" in Geiser, Samuel Wood. *Naturalists of the Frontier.* (341 pp. Southern Methodist University. 1939.) Two asterisks (**) indicates the person is one of the ten given special treatment in Geiser's excellent work. [Plant collectors mentioned by Geiser who are not included in the present study are: 1839 Artemas Bigelow, (Dr.) W. L. Diffenderfer (collections at Gray Herbarium of Harvard?), David Douglas, 1849-1855 Louis Cachand Ervendberg (collections at Gray Herbarium of Harvard?), 1820 (Dr.) Edwin James, 1854-1857 (Dr.) Caleb Burwell Rowan Kennerly, 1852-1858 (Captain) Edmund Kirby-Smith, 1820 (Major) Stephen Harriman Long, 1836 John W. Moore, 1850-1856 (Dr.) Heinrich Poselger, 1845 Louis Reinhardt, 1839 John Leonard Riddell, 1849-1855 August Siemering, 1836 (Dr.) John Allen Veatch (collections in the herbarium of the California Academy of Sciences?), 1838-1844 (Dr.) Eduard Wiedemann (collections in the herbarium at St. Petersburg-). In addition to the plant collectors the following botanists and horticulturists are mentioned who might have been expected to leave specimens, but for whom no specimens were found: 1853-1854 (Lieutenant) Darius Nash Couch, 1831 Friedrich Ernst, (Dr.) Ferdinand Ludwig Johann von Herff, 1854-1857 Frederic Law Olmsted, 1855 James Shinn, 1851 Adolph Strauch, 1865 (Mrs.) Maude Jeannie Young.]

Column **1** *(Tch)* shows the distribution of the 16270 specimens of Texas plants contributed by 193 collectors as represented in the Chicago Natural History (Field) Museum Herbarium. Column **2** *(DI)* gives the numbers of herbaria in which each of the 229 collectors tabulated in a series of monographs are represented. Column **3** *(TM)* indicates the number of specimens for each collector for the 2328 specimens cited in a series of monographs (see text). Column **4** *(TFl)* shows the number of specimens for each collector for the 4907 specimens cited in four parts of C. L. Lundell's *Flora of Texas.* Column **5** *(CI)* gives the number of herbaria in which each of the 989 collectors are represented in the herbaria of Texas. Column **6** *(THe)* tabulates the number of specimens of each collector in the herbaria of Texas as sampled in 26078 specimens tabulated in this study (approximately one-fifth of each herbarium. For explanation of method of sampling see text.)

Column "**7** to **44**" shows the number of specimens of each collector in each Texas herbarium tabulated in this study. The symbols used, the total number of *specimens* tabulated in each herbarium, and the number of collectors represented in each herbarium, respectively, in column "7 to 44," are as follows: *Ahs* Austin Senior High School Herbarium, *16,* **11**; *AR* Albert Ruth Collection at the Fort Worth Botanical Gardens, *142,* **8**; *ATc* S. F. Austin State Teacher's College Herbarium, *236,* **5**; *Bg* E. R. Bogusch Collection at the College of Arts and Industries, *374,* **11**; *BU* Herbarium of Baylor University, *638,* **41**; *Dnh* Scruggs Herbarium of Dallas Natural History Museum, *25,* **8**; *HB* Herbarium of Mary Hardin-Baylor College, *141,* **17**; *Hi* L. C. Hinckley Herbarium, *221,* **2**; *HM* Herbarium of Houston Public

Museum in Hermann Park, *341*, **6**; *Ho* Herbarium of the University of Houston, *180*, **23**; *JT* Herbarium of John Tarleton Agricultural College, *151*, **12**; *McC* Wm. L. McCart Collection at the Fort Worth Botanical Gardens, *617*, **54**; *MM* Herbarium of the Texas State Memorial Museum, *196*, **1**; *oL* Herbarium of Our Lady of the Lake College, *233*, **9**; *RR* Robert Runyon Herbarium, *226*, **1**; *RV* Robert Vines Herbarium, *83*, **4**; *Sa* G. L. Saxman Fern Herbarium*, *167*, **9**; *Sc* Herbarium of the U. S. Soil Conservation Service (at Amarillo), *70*, **12**; *SG Silveus Grass Herbarium*, *326*, **2**; *Si* Sinclair Collection at the College of Arts and Industries, *85*, **9**; *SM* C. L. Lundell Herbarium of Southern Methodist University, *1056*, **33**; *Sp* O. E. Sperry Herbarium, *179*, **4**; *SRW* S. R. Warner Collection at Sam Houston State Teacher's College, *661*, **4**; *Sw* Herbarium of Southwestern University, *74*, **17**; *Ta* Tracy Herbarium of the Texas Agricultural and Mechanical College, *4077*, **134**, *TcW* Herbarium of the Texas State College for Women, *113*, **17**; *Tet* East Texas State Teacher's College Herbarium, *137*, **17**; *Th* Thurow Collection of Sam Houston State Teacher's College, *564*, **6**; *Tr* Herbarium of Trinity University, *71*, **9**; *Ts* Herbarium of North Texas State College of Mines, *33*, **14**; *TPh* Pharmocognosy Herbarium of the University of Texas, *348*, **12**; *TPv* Herbarium of Prairie View State College, *99*, **37**; TR Herbarium of Sul Ross State Teacher's College, *391*, **13**; *Tr* Herbarium of Trinity University, *71*, **9**; *Ts* Herbarium of North Texas Teacher's College, *1192*, **70**; *Tt* E. L. Reed Herbarium of Texas Technological College, *676*, **30**; *Txl* University of Texas Herbarium, *11001*, **582**; *Txal* Cotton Root Rot Project Herbarium of the Texas Blackland Experimental A. & M. Substation, *614*, **13**; *WM* Herbarium of the Witte Memorial Museum, *996*, **38**.

Column "**45 to 93**" tabulates the number of specimens of each collector of Texas plants as cited in a random list of monographs. (The asterisks (*) indicate herbaria in which important collections have been deposited by prominent collectors of Texas plants as listed by Pennell.) The symbols used, the total number of specimens tabulated for each herbarium, and the number of collectors represented for each herbarium, respectively, in column "45 to 93," are as follows: **Ah** Arnold Arboretum Herbarium of Harvard University, 9, *6;* **Ar** Herbarium of the University of Arizona, 3, *2;* **B** Botanisches Museum, Berlin-Dahlem, Germany, 5, *4;* **Bm** Herbarium of the British (Natural History) Museum, London, 4, *5;* **Ca** Langlois Herbarium of the Catholic University of America, 11, *3;* **Cb** Herbarium of the University of California at Berkeley, 21, *13;* **Cm** Herbarium of the Carnegie Museum of Pittsburgh. 9, *5;* **Co** Herbarium of Cornell University, 7, *3;* **Cs** Herbarium of the California Academy of Science, 28, *11;* **DC** de Candolle Herbarium, 7, *2;* **Dd** Dudley Herbarium of Stanford University, 15, *7;* **De** Herbarium of the Society of Natural History of Delaware, 4, *3;* **Fm** Phanerogamic Herbarium of the Chicago Natural History (Field) Museum, 110, *34;* **Gh** Gray Herbarium of Harvard University, 164, *42;* **Ill** Herbarium of the University of Illinois, 2, *2;* **Iw** Herbarium of the University of Iowa, 0, *2;* **K** Herbarium of the Royal

* Since this was prepared this herbarium has become the nucleus of the "G. M. Saxman Fern Collection of the University of Texas."

Botanic Gardens, Kew, 47, *13;* **Ka** Herbarium of Kansas State Agricultural College, 0, *1;* **Kn** Herbarium of Kansas State University, 0, *1;* **L** Herbarium of Tulane University, 19, *1;* **Ls** Herbarium of Louisiana State University, 6, *2;* **M** Herbarium of the Missouri Botanical Garden, 536, *67;* **Mc** Herbarium of the University of Michigan, 15, *11;* **Mn** Herbarium of the University of Minnesota, 15, *13;* **Mw** Herbarium of the Milwaukee Public Museum, 3, *2;* **ND** Herbarium of the University of Notre Dame, 15, *9;* **O** Herbarium of Ohio State University, 5, *4;* **Ok** Herbarium of the University of Oklahoma, 5, *4;* **Or** Herbarium of the University of Oregon, 1, *1;* **P** Herbarium, Museum d'Histoire Naturelle, Paris, 2, *2;* **Pe** Herbarium of the University of Pennsylvania, 51, *5;* **Po** Herbarium of Pomona College, 62, *12;* **Ph** Herbarium of the Philadelphia Academy of Natural Sciences, 232, *69;* **R** Rocky Mountain Herbarium of the University of Wyoming, 17, *4;* **S** Herbarium of Charleston Museum, 4, *1;* **Sd** Herbarium of South Dakota State College, 0, *1;* **T** Herbarium of the University of Tennessee, 3, *2;* **Tx** University of Texas Herbarium, 170, *60;* **Txa** Cotton Root Rot Project Herbarium of the Texas Blackland Experimental A. & M. Substation, 18, *5;* **U** United States National Herbarium of the United States National Museum, 379, *79;* **V** Vienna Herbarium, 2, *2;* **Va** United States Department of Agriculture's National Arboretum Herbarium, 5, *3;* **Ve** Herbarium of the University of Vermont, 0, *1;* **Y** New York Botanical Garden Herbarium, 263, *60;* **Yl** Herbarium of Yale University, 1, *1;* **Yp** Herbarium of the New York College of Pharmacy, 0, *1.*

PHANEROGAMIC HERBARIUM, CHICAGO NATURAL HISTORY MUSEUM
CHICAGO, ILLINOIS.
HERBARIUM, DEPARTMENT OF BOTANY AND BACTERIOLOGY, UNIVERSITY OF TEXAS
AUSTIN, TEXAS.

TABLE 2

Texas collections†	Texas plant collectors	1 TCh	2 DI	3 TM	4 TFI	5 CI	6 THe	7—44	45—93
1939	Adams, Bess				2	2	13	5*Ts*, 8*McC*.	
1937-1938	Adams, Exa				5	2	49	38*Ts*, 11*McC*.	
1922	Adams, H.					1	1	1*WM*.	
	Adams, Laura		1	1					1Tx.
1936-1942	Adams, R. H.					1	24	24*ATc*.	
1937-1938	Akin, Berta					1	6	6*Txl*.	
1931-1944	Albers, C. C.					3	316	314*TPh*,1*TPc*,1*Stc*.	
	Albrecht, Olin					1	1	1*Txl*.	
1935	Aldwell					1	1	1*Ta*.	
1939	Alex, A. H.					1	2	2*Ta*.	
	Allen, C. K.				2				
1914-1920	Allen, Ena Elida				1	2	28	27*Txl*, 1*TPc*.	
	Alstatt, R. A.				1				
1920	Anderson, Yvonne				3	1	3	3*WM*.	
1939	Anderson, E.				1	2	10	7*Ts*, 3*McC*.	
1855	Antisell, Thomas	1							
1930	Apeliner, Conrad					1	1	1*Txl*.	
	Appleman, D.				1				
1927-1929	Armer, Annie A., (Sr. Joseph Marie)				8	2	63	62*Txl*, 1*TPc*.	
1921	Ashe, Herbert					1	4	4*WM*.	
	Ashe, W. W.		1	1	1				1Ca.
1934	Ashley, Evelyn					1	1	1*Txl*.	
1939	Ashworth, Mary E.				1	1	5	5*Ts*.	
1926-1935	Babcock, O. G.				1	1	2	2*Ta*.	
1930	Babel, Helen					1	1	1*Ahs*.	
	Babs, LeRoy					1	1	1*Txl*.	
1929	Bach, W. J.					1	1	1*Txal*.	
1917	Bailey, E. A.					1	1	1*Txl*.	
1938	Bailey, Edward L.					1	2	2*Sp*.	
	Bailey, Effie					1	1	1*Txl*.	
	Bailey, E. Z.				1				
1931	Bailey, Liberty Hyde		4	2	21				*Co, *Mn, 1Ph, 1U.
1901	Bailey, V.				3	1	1	1*Txl*.	
1939-1940	Bain, D. C.				1	1	12	12*Ta*.	
	Baird, J. A.				2				
1935-1936	Baird,(Mrs.) Josephine A.					1	16	16*oL*.	
1931	Baker, Bryant O.					1	15	15*Txl*.	
1940	Baker, Virginia					1	1	1*Tet*.	
	Balcom, (Mrs.) W. S.				1				
1906-1907	Ball, Carleton Roy	6			10				
	Ball, C. S.				1				
	Ball, J.		6	7					1Cl, 1DC, 1M, 1Ph, 2U, 1Y.
1934	Ball, Mary J.					3	3	1*Txl*, 1*TPc*, 1*TM*.	
1904-1906	Ball, O. M.				1	1	6	6*Ta*.	
1941	Ball, (Mrs.)					1	1	1*Tet*.	
1938	Ballard					1	1	1*Tet*.	
1931	Barber, Lucille					1	1	1*Txl*.	
	Barlo		1	1					1Cb.
1911	Barlow, Bronson	209	3	3	3				1Cs, 1Fm, 1U.
1929	Barker, Paul					1	4	4*Txl*.	
1934-1944	Barkley, Fred Alexander		1	3	1	2	3	2*Txl*, 1*JT*.	3M.
1932	Barkley, LeRoy					1	1	1*Txl*.	
1939	Barrett, Bernice					1	9	9*BU*.	

† Dates cited are inclusive.

TABLE 2 (Continued)

Texas collections†	Texas plant collectors	1 TCh	2 DI	3 TM	4 TFI	5 CI	6 THe	7—44	45—93
1928-1933	Barrow, Louise				2	1	5	5*Txl.*	
1913-1921	Batholomew, Elam	19							
1905	Bartlett, H. H.					1	7	7*Txl.*	
1935	Barton, J. A.					1	1	1*Ta.*	
1939	Bass, P.				1	2	9	4*Ts*, 5*McC.*	
1931	Bastian, Melba				1	2	9	4*Ts*, 5*McC.*	
----------	Bates, Leroy					1	1	1*Txl.*	
1939	Bayer, Arthur					1	1	1*Sw.*	
1939	Beal, Eva Ruth					1	13	13*BU.*	
1939	Beard, Dearl					1	5	5*TR.*	
1927	Beattie, Frederick S.		1	2					2Ph.
1933	Beazley, Mary Alice					1	2	2*Txl.*	
1903-1905	Bebb, Robert	177			6				
1870	Bechdolt, Robert G.	1			1				
1937	Beck, E.				1				
1900	Beck, Mary Anne					1	2	2*Txl.*	
----------	Beckham, T.		1	1	1				1Ph.
1930	Beckman, Thelma		1	1		1	2	2*Txl*	1Tx.
1930-1932	Beede, Francis				3	1	5	5*Txl.*	
1944	Bedingfield, Morris					1	1	1*TPh.*	
1929	Bedingfield, Opal					1	2	2*Txl.*	
1934	Beheler, Lloyd					1	1	1*Txl.*	
----------	Beilmann, A. P.				1				
1942	Bell, Betty Jean					1	9	9*Ho.*	
1930	Bell, Josie					1	13	13*Tr.*	
1938	Belser, Lloyd					1	9	9*ATc.*	
1934	Belsterling, (Mrs.) Eda A.					1	1	1*Sa.*	
1932-1933	Benedict, Dolores					1	2	2*Txl.*	
1932	Bengel, Elaine					1	1	1*Txl.*	
1932	Bengel, Margaret					1	2	2*Txl.*	
1928-1930	Behnke, Harmann Conrad	288	4	4	11				2Fm, *Mw, 1Po, *1Ph.
1936-1937	Bennett, Ralph W.					3	11	2*Txl*, 1*Ta*, 8*Sc.*	
1937	Benson, J. E.					1	32	32*TR.*	
1897	Bentley, Bartram Henry	1							
1921-1925	Berkman, Anton Hilmer		1	3	5	1	50	50*Txl*	3Tx.
1828-1830	**Berlandier, Jean Louis	136	5	11	33				*1Fm, *4Gh, 1K, 4M, *1Ph.
1935	Beth, Nora					1	1	1*Txl.*	
1939	Bibby,					1	2	2*Txl.*	
1850-1854	*Bigelow,(Dr.) John Milton	57	3	4	17				2Gh, *1U, *1Y.
----------	Bindwall, K.				1				
----------	Bink,		1	1					1Tx.
----------	Birge, Juanita					1	1	1*Txl.*	
1909-1910	Birge, Willia Isabella					1	4	4*Txl.*	
1922	Birkhead, Nancy					1	1	1*HB.*	
1928	Black, H.					1	1	1*Txl.*	
1939	Black, Lester					1	10	10*BU.*	
----------	Blackburn, J.		1	1		1	1	1*Txl*	1Ph.
1939	Blackwell, Carrie				3	3	26	1*Txl*, 8*Ts*, 17*McC.*	
1911	Blair, R. E.		3	4	3				2M, 1Mc, 1Tx.
----------	Blake, W. P.		1	1	1				1Y.
1938	Blanton, Billie					1	1	1*BU.*	
1931	Blitch, George					2	2	1*Txl*, 1*McC.*	
1938	Blumentritt, M.					2	3	1*Ts*, 2*McC.*	
1891	Bodeau,		1	1	1				1Mn.
1889-1891	Bodin, J. E.	38	2	3	4				*1Mn, 1Ph, *Kn.
1926-1937	Bogusch, Edwin Robert	19	3	7	31	9	386	166*Txl*, 2*Ts*, 3*SM*, 205*Bg*, 1*Tet*, 1*TPg*, 18*Sw*, 1*TM*, 1*Tll.*	1Ph, 2Tx, *4U.

TABLE 2 (Continued)

Texas collections†	Texas plant collectors	1 TCh	2 DI	3 TM	4 TFI	5 CI	6 THe	7—44	45—93
1930	Bogusch, E. Molly	1			1				
1927-1930	Bogusch, (Mrs.) R. C.					1	2	2*Bg.*	
	Boigt,				1				
1869-1880	**Boll, J.	1			9				
1934	Bolzte, William (Billie)					1	1	1*Txl.*	
1932	Bone, Genevieve					1	1	1*Txl.*	
1931-1933	Booker, Josephine				1	1	17	17*Txl.*	
1930-1936	Boon, Effie				19	4	159	152*Txl*, 1*Sa*, 2*TPt*, 4*Sw.*	
1903	Booth, E. S.					1	6	6*Ta.*	
1939	Boren, Ethyl					1	6	6*McC.*	
1931	Boring, Ruth					1	1	1*Txl.*	
1936	Bowser, Perry					1	1	1*Tt.*	
	Boyd, E. H.	35							
1938-1939	Brackett, Eunice Sarah				3	1	71	71*Txl.*	
1930	Brandt, Gertrude					1	2	2*Txl.*	
1897-1904	Bray, William L.	1	3	13	30	1	177	177*Txl.*	5Tx, *7U, *1Y.
1910	Breuer, Miles J.					1	4	4*Txl.*	
1934	Brewer, R. C.					1	4	4*Txl.*	
	Bridge, Josiah		1	1					*1Ci.
1934	Bridewell, W. A.					1	1	1*Dnh.*	
1936	Briggs, Herbert					1	10	10*ATc.*	
1937	Bright, John					1	2	2*Txl.*	
1932	Brillhart, Elmer					1	1	1*Txl.*	
1937	Brinckley, Elizabeth Emma				1	1	10	10*Txl.*	
1932	Britton, Grady					1	1	1*Txl.*	
	Broadhead, Garland Carr		1						*M.
1933	Brock, G. L.					1	1	1*HM.*	
1935	Brooks, B. B.					1	1	1*Ta.*	
1933	Brooks, Josephine					1	6	6*Txl.*	
1934	Brooks, L. E.					1	5	5*Txal.*	
	Brown, Dora May					1	1	1*Txl.*	
1940	Brown, E. E.					1	2	2*Ta.*	
	Brown, Farris					1	2	2*Txl.*	
	Brown, Frankie					1	1	1*Txl.*	
	Brown, Lella Griffen					1	1	1*HB.*	
1930	Brown, Louise					1	1	1*Txl.*	
1939	Browning, L. L.					1	5	5*ATc.*	
1933	Brozelton, Merle				1	1	1	1*Txl.*	
1939	Bryant, I. B.				1	2	9	3*Ts*, 6*McC.*	
1937-1939	Bryant, M. D.					1	15	15*Ta.*	
1922	Bryen, Ivy Jewell					1	1	1*HB.*	
1937	Buck, Gus					1	1	1*McC.*	
	*Buckley, Samuel Botsford	18	3	3	3	1	1	1*Txl.*	*M, *3Ph, *Y.
1891	Budd, Henry I.	1							
	Bullington, E.					1	1	1*Txl.*	
1934	Burke, Randall					1	4	4*Txl.*	
1932	Burrows, J.					1	1	1*Txl.*	
1935	Burwell, Robert					1	1	1*Txl.*	
1900-1909	Bush, Benjamin Franklin	16	8	26	46				1De, 1Gh, 1K, *14M, 2Nd, 1Ph, 2U, 4Y
1880	Butler, George D.	1							
1940	Buttrill, Hearon					1	1	1*McC.*	
1932	Bybee,					1	2	2*Txl.*	
	Byers, J.		1	1					1Gh.
	Byers, C.					1	2	2*Txl.*	
	Cagmond, Frances					1	1	1*Txl.*	
1937	Cameron, Chas. E. R.	165			2	1	34	34*Txl.*	

TABLE 2 (Continued)

Texas collections†	Texas plant collectors	1 TCh	2 DI	3 TM	4 TFI	5 CI	6 THe	7—44	45—93
1926	Camp, E. W., Jr.					1	3	3*Tt.*	
----	Camp, R. D.				1				
1926	Campbell, Myrtle					1	1	1*WM.*	
1921	Canady, John E.					1	2	2*WM.*	
1874	Canby, William Marriott	1	6	2	1				*1De, *Fm, *Gh, *Ph, *1U, *Yp.
----	Cannon, A.				1				
1938	Cannon, (Mrs.) C. D.					1	1	1*WM.*	
----	Cannon, H. B.				5				
----	Cannon, M.				6				
1929-1944	Capt, Lucile	4				1	120	120*HB.*	
1932	Cardwell, Otis					1	1	1*Txl.*	
1936	Cardwell, M.					1	1	1*Tt.*	
1924	Carike, Josephine					1	2	2*TcW.*	
1891	Carleton, Mark Alfred	7			2				
1915	Carlson,		1	1	1				1Cs.
1938	Carpenter, Daniel E.					1	2	2*Tt.*	
1910-1911	Carr, William Phillips	25							
----	Carruthers, W.				1				
1911-1912	Carsner, E.				2	1	9	9*Txl.*	
1942	Carter, Jean					1	1	1*Ho.*	
1927	Carter, N.		1	1	2	1	1	1*SM*	1Va.
1927	Carter, W. C.					1	1	1*Ta.*	
1923	Castleberry, Wanda					1	2	2*Txl.*	
1941	Cates, Francis W.					1	13	13*ATc.*	
1930	Caulkins, Ford					1	1	1*Txl.*	
1938	Center, Nadine					2	8	4*Te*, 4*MeC.*	
1933-1934	Chambers, Ben R.				6	1	19	19*Txl.*	
----	Chambers, T. S.				1				
----	Chandler, Harley Pierce		6	3	3				*Cl, 1Gh, *Mn, *Tx, 1U, 1Y.
1911	Charlton, Orlando Clarke	1							
1912	Chase, M. Agnes	3	1	1	10	1	1	1*Txl.*	
1928-1931	Chateau, I.	56			1				
----	Cheng, W. C.				1				
1934	Cheves, M.				1				
----	Chickering, John White, Jr.	1							
1936	Chiplin, Jack					1	1	1*Tt.*	
1931	Chipps, (Mrs.) J. F.					1	1	1*Txl.*	
----	Clapp, B.		2	2					1Ph, 1Tx.
----	Clark, J. H.				1				
1939	Clark, Waddie		1	2		1	10	10*BU*	2M.
----	Clarke,				1				
1917	Clawson, A. B.	1	1	2	1				2U.
1911	Clemens, Joseph	9	5	13	28	1	9	9*Txl*	1Cs, 6M, 3Po, 1R, 2Y.
1911	Clemens, (Mrs.) Mary Knapp.	16	6	13	32	1	9	9*Txl*	1Cs, 6M, 3Po, *Ph, *1R, 2Y.
1938	Cliburn, Hilda	5				1	1	1*ATc.*	
1932-1934	Clover, Elzada U.				54	2	73	69*Txl*, 4*SM.*	
1937	Cogsdell, R. R.					1	1	1*Txl.*	
1937	Cole, John J.					1	1	1*BU.*	
1934	Cole, Kenneth					1	1	1*Txl.*	
1939	Cole, Lamar					1	19	19*BU.*	
1940	Coleman, H. S.					1	14	14*Ta.*	
----	Colley, Marie					1	1	1*Txl.*	
1921-1931	Combs, J. F.					2	2	1*Ta*, 1*Txal.*	
1937	Connar, A. B.					1	4	4*Ta.*	
1929	Cook, G. M.	1							

TABLE 2 (Continued)

Texas collections†	Texas plant collectors	1 TCh	2 DI	3 TM	4 TFI	5 CI	6 THe	7—44	45—93
1937	Cook, R. R.					1	14	14*TR.*	
1930	Cooper, Irma					1	2	2*Txl.*	
1930	Cooper, Owania					1	1	1*Txl.*	
1927	Cornell, Lulu					1	4	4*Txl.*	
1930	Corrasco, Leyse					1	1	1*Txl.*	
1924-1944	Cory, Victor L.	12	4	49	486	7	1801	3*Txl*, 1774*Ta*, 18*M*, 3*Txal*, 3*HM*, 12*Ho*, 6*RV*.	3Fm, 1M, 30Po, 15U.
1919	Cothran, E. W.		1	1	1	1	3	3*Ta*	1Po.
1926-1931	Cottle, H. J.				5	1	142	142*TR.*	
	Cottom, W. P.				3				
	Cottrell, Paul				1				
1930-1931	Cottrell, (Mrs.) Paul				2	1	5	5*Txl.*	
1930	Couch, J. E.					1	1	1*Tt.*	
1910	Coulter, John Merle	2							
1931	Cowan, Helen					1	2	2*Txl.*	
1939	Cox, Adele					1	2	2*McC.*	
1935	Cox, Martha Ermma					1	1	1*Tt.*	
	Cox, T.				1				
1930	Crabill, Billie					1	5	5*Txl.*	
1934	Craig, T.				1				
1931	Cranfield, Parks					1	1	1*Txl.*	
1892	Crawford, E. W.	62							
1893	Crawford, Joseph	1							
1930	Crawford, R.					1	7	7*ATc.*	
1853-1860	*Crawford, (Dr.) Samuel Wylie.				1				
1933	Creighton,		1	1					1M.
	Crockett, George L.		1	3	3				*3U.
1942	Crockett, R. L.					1	1	1*Txl.*	
1885-1888	Croft, Mary B.	13	1		14				*U.
	Crofts,		4	8					1M, 1Nd, 1U, 5Y.
1927-1937	Cross, J. C.				1	1	6	6*Txl.*	
1940	Cross, Price					1	1	1*Txl.*	
1931	Crossley, Emmett					1	1	1*Txl.*	
1898	Crow,					1	1	1*Ta.*	
1934	Crowley, Brian					1	2	2*Txl.*	
1939	Culwell, Walton				1	3	9	2*Txl*, 5*Ts*, 2*McC.*	
1938-1941	Curry, Odis J				2	2	36	35*Ta*, 1*TR.*	
	Curtiss, A. H.		3	3					1Gh, 1U, 1Y.
1937-1938	Cutler, Hugh C.	5			5	1	7	7*Ta.*	
1926	Cuyler, Esther					1	2	2*Txl.*	
1934	Cypher, Al					1	2	2*Txl.*	
1933	Dacon, Betty Jo					1	1	1*Txl.*	
1929-1936	Dana, B. F.		1	1		2	16	7*Ta*, 9*Txal*	1Txa.
1931	Dance, Johnnie					1	2	2*Txl.*	
1930	Daniel, Annie L.					1	1	1*Txl.*	
1877-1881	Dapprich, Emil		1	3					*3Mw.
1933	Darnall, (Mrs.) J. L.					1	1	1*Dnk.*	
1930	d'Aston, Joshua S.	15							
1941	Daugherty, F. Morton, Jr.					1	8	8*Ho.*	
1935	Davenport, W. H.					1	1	1*Dnk.*	
1941-1942	Davis, (Mrs). Anna May Tarrence.					4	62	60*Txl*, 1*TPc*, 1*Sw.*	
	Davis, A. R.				1				
1930	Davis, Johnnie					1	1	1*Txl.*	
1941	Davis, L. Irby					1	3	3*Txl.*	
1939-1940	Davis, W. B.				1	1	26	26*Ta.*	

TABLE 2 (Continued)

Texas collections†	Texas plant collectors	1 TCh	2 DI	3 TM	4 TFI	5 CI	6 THe	7—44	45—93
1931	Dawson, F. W.					1	1	1*WM.*	
1934	Dawson, LeRoy					2	2	1*Txl*, 1*TM.*	
1931	Day, Wanda		1	1		1	1	1*Txl.*	
1941	Deam, Charles C.					1	5	5*JT.*	
1931-1937	Deaton, Dahlia		2	2	2	1	15	15*Txl*	1Ph, 1Tx.
1940	Dees, Margaret					1	2	2*BU.*	
----------	Degener, Otto		1	1	7				*1Y.
----------	Delebano, B.				1				
1930	Demaree, Delzie		4	10	9	2	36	1*Txl*, 35*Tt*	2Gh, *5M, *Ph, *3U
1932-1943	Denny, Grace					1	102	102*Tct.*	
1932	Denton, Dolores					1	2	2*Txl.*	
1920	Denton, (Mrs.) J. M.					1	1	1*Txl.*	
1933	Deveny, James H.					1	4	4*Txl.*	
1891	Dewey, Lyster Hosie	1							
----------	Dias, M. K.				1				
----------	Diaz, N. R.					1	2	2*Txl.*	
----------	Diehl, I. E.				2				
1940	Diercks, Fred					1	1	1*Tct.*	
1936	Diez, Nico (Nick)					1	3	3*Txl.*	
----------	Diffenderfer, F. R.				1				
1938	Dismuke, Jerry					1	1	1*Tct.*	
1911	Ditmars, Guido	1			1				
1908-1911	Dixon, Royal Absalom	557	6	11	23				*3Fm, 1Gh, 2M, 1Ph, 1U, *3Y.
1938-1939	Dobbins, M.				1	2	16	3*Ts*, 13*McC.*	
1930-1931	Dobie, (Mrs.) J. Frank		1	1	1	1	5	5*Txl.*	
1914-1916	Dodd, S. H.				1	1	7	7*Txl.*	
----------	Dodge, C. K.				1				
1941	Dougherty, Frank P.					2	10	2*Txl*, 8*WM.*	
1934	Dowd, Phillip					1	1	1*Txl.*	
1833-1834	**Drummond, Thomas	5	7	23	19				1Ah, 1De, 5Gh, *5K, 1Ph, 1V, 9Y, *2M, *0.
----------	Drushel, S. G.		2	2					1Ph, 1U.
1921	Duncan, C. D.		4	19	20				6Co, 6DC, 4Ls, 3Va.
----------	Dunn, G. W.		1	1	1				1Cl.
----------	Durand, Elias Judah	6							
1930	Durrow, J. Lee					1	2	2*Txl.*	
1921-1928	Duval, Hugh H.	3	1	2	6	2	233	37*Txl*, 196*MM.*	
----------	Earle, E. S.				1				
1902	Earle, Franklin Summer	88	13	59	16	3	35	24*Txl*, 10*Ta*, 1*SM.*	
1925	Ebbersol, Minnie					1	2	2*TcW.*	
1933	Edwards, Mary Taylor Mueller.				2	1	3	3*Txl.*	
1931	Egg, Mamie		1	1	2	1	22	22*Txl*	1Tx.
1898-1901	Eggert, Heinrich (K. D.)	7	5	44	67	1	1	1*AR*	1Cm, 1Gh, *39M, 1U, 2Y.
1920	Eggleston, Willard Webster.	36	7	10	5				*Gh, 2M, 1Mc, 1Ph, 1Tx, *2U, *3Y.
1938	Ehlers, Edith					1	7	7*ATc.*	
----------	Eifrig, C. W. G.				5				
1924-1926	Eifrig, G.	20			3				
----------	Eiland, K.		1	1					1Ph.
1942	Elliott, Harold					1	4	4*Ho.*	
----------	Engelmann, G.		1	1	2				1M.
1930	English, Claudia				1	1	2	2*Txl.*	
----------	English, Effie D.					1	1	1*HB.*	
1925	Erlandson, Carl Oscar		1	1	10	1	7	7*SM.*	
1939	Ethridge, Evelyn					1	1	1*Sp.*	

TABLE 2 (Continued)

Texas collections†	Texas plant collectors	1 TCh	2 DI	3 TM	4 TFI	5 CI	6 THe	7—44	45—93
1929	Evans, Charles H.					1	1	1*Txl.*	
1891	Evans, Walter Harrison	12							
1938	Everett, N. B.					2	7	4*Ts*, 3*McC.*	
1929	Ezell, Aubrey					1	1	1*Txl.*	
1928	Faifer, Robert					1	1	1*Txl.*	
1885	Farlow, William Gibson	1			1				
1930	Farquhar, Bryda Mae					1	1	1*Txl.*	
	Farr, E. M.					1	1	1*Txl.*	
1839-1855	*Fendler, Augustus	1			2				
1891-1902	Ferguson, A. M.					3	127	113*Txl*, 13*Ta*, 1*Sa.*	
1921	Ferguson, B.				10	1	2	2*Txl.*	
	Ferguson, Ira					1	1	1*Txl.*	
1921	Ferris, Roxana J.		4	23	20				7Cs, 5Dd, 5M, 6Y.
1903	Feriss, James Henry	11							
1933	Fie, N. B.					1	1	1*Txl.*	
1929	Fields, Joseph					1	1	1*Txl.*	
1927	Finley, I. O.				1	1	1	1*Txl.*	
1934	Finsley, Norma					1	1	1*Txl.*	
1937	Fisher, C. E.					1	3	3*Ta.*	
1912-1939	Fisher, George Lewis	732	4	8	51	7	417	8*Ta*, 37*WM*, 291*HM*, 2*oL*, 49*Ho*, 2*Sa*, 28*RV.*	2Fm, 1M, 2Ph, *3U.
1930	Fisher, Myra					1	1	1*Txl.*	
1913	Fitch, William R.		1	1	1				1Fm.
1932-1933	Fitzhugh, Arba					1	3	3*Txl.*	
1934	Fitzhugh, Paris					2	9	8*Txl*, 1*TPe.*	
1942	Fleetwood, Billy					1	2	2*ATc.*	
1934-1937	Flemming, Pat				2	1	9	9*Txl.*	
1928-1929	Fletcher, H. T.	5			2	1	7	7*WM.*	
1939	Fling, Roy					1	1	1*Tet.*	
1941	Flippin, Welch					1	11	11*Tet.*	
1941	Flory, W. S.					1	6	6*Ta.*	
1930	Flower, Helen					1	1	1*Txl.*	
1931	Floyd, P. L.					1	1	1*Txl.*	
1931-1932	Flynt, Edith					1	6	6*Txl.*	
1942	Forcum, Phyllis					1	3	3*Ho.*	
1939	Ford, Albert					1	1	1*Ts.*	
1938	Ford, Ernest					1	11	11*ATc.*	
1930	Fordyce, Sam					1	6	6*Txl.*	
1855-1857	*Forshey, Caleb Goldsmith	19	1	4					*4Ph.
1939	Fortner, John					1	19	19*BU.*	
1936	Fosberg, F. R.				1				
	Foster, Guy T.					1	2	2*Txl.*	
1934	Fough, (Mrs.)					1	2	2*Txl.*	
	Frances, Ellen					1	5	5*Txl.*	
1935	Francke, Dolores					1	2	2*Txl.*	
1941	Francis, H.					1	4	4*ATc.*	
	Freeman, A.				1				
1937	Friend, W. H.					1	3	3*Ta.*	
1934	Friesner, Ray C.					1	1	1*Txl.*	
1942	Fults, Jess L.					1	1	1*Sc.*	
	Gabriel, (Miss) A.				1	1	2	2*Txl.*	
	Gahwiler, O. G.				1				
1939	Galloway, H. C.					1	3	3*McC.*	
	Gander, F. F.				1				
1932	Garner, James					1	1	1*Txl.*	
1930	Garza, Cristobel					1	1	1*Txl.*	
	Garza, G.		1	1		1	1	1*Txl.*	1Tx.

TABLE 2 (Continued)

Texas collections†	Texas plant collectors	1 TCh	2 DI	3 TM	4 TFI	5 CI	6 THe	7—44	45—93
						1			
1930	Garza, John						1	1*Txl.*	
1928	Geelan, Charles William					1	1	1*Txl.*	
1933	Geib, A. V.				1	1	5	5*Ta.*	
	Geiser, S. W.				15				
1929	Gengnagel, Robert					1	2	2*SM.*	
1927	German, Wilmer					1	2	2*Txl.*	
	Gieger, L. L.					1	1	1*Txl.*	
1928	Giesenschlag, (Mrs.) A.		2	5		1	7	7*Txl*	3Ph, *2Tx.
1934	Giessett, Ray					1	5	5*Txl.*	
1933	Gilchrist, Chreighton		1	1		1	1	3*Txl*	1Gh.
1932	Gill, Martha Jane				1	1	6	6*Txl.*	
	Gill, T.				1				
	Gillespie, John Wynn				1				
1880	Girard, Joseph Basil		1	1	1				1Gh.
1940-1941	Girvin, Eb.				4	2	65	65*Txl.*	
1929	Givens, Ora					1	1	1*Txl.*	
1940	Glass, Bryan P.					1	1	1*BU.*	
1926	Glass, H. Bentley					1	4	4*BU.*	
1906	Glass, W. V.					1	1	1*Ta.*	
	Glatfelter, Edith E.				1				
1940-1941	Glazener, W. C.					2	6	4*Txl*, 2*Ta.*	
1939	Glover, Leonora					1	1	1*McC.*	
1932-1941	Goldsmith, G. W.		1	1		1	6	6*Txl*	1Tx.
1934-1935	Goodman, George Jones		1	1	4				1M.
1936-1940	Goodrum, Phil				2	1	9	9*Txl.*	
1929	Gore, U. D.					1	2	2*Ta.*	
1920-1930	Gough, Lula Cass		1	2	7	2	181	52*Txl*, 129*JT*	2Ph.
1934	Gragg, F.					2	4	3*Txl*, 1*TPe.*	
1932	Graham, George				1	1	5	5*Txl.*	
1935	Graham, H. L.					1	11	11*Ts.*	
1940	Grammar, Frances					1	1	1*Ts.*	
1930	Grassl, Carl O.	76	1	1	6				1Fm.
1931	Graves, Henry					1	2	2*Txl.*	
	Graves, (Mrs.)					1	1	1*Ta.*	
1931	Gray, Nell		2	2		1	1	1*Txl*	1Tx, 1U.
1933	Gregg, Shirley					1	1	1*Txal.*	
	Griffith, Dennis E.				1	1	1	1*Txl.*	
1936	Griffith, Elbert		1	1		1	1	1*TPh*	1Y.
1903-1905	Griffiths, David	17	4						*Mn, *U, *Y, *Sd.
1931	Griffiths, Virginia		1	1		1	2	2*Txl*	1M.
1933	Griggs, Thomas		1	1	2	1	5	5*Txl*	1M.
1903-1905	Groth, Benno Humbert Alfred.	213	5	9	13				*3Fm, *2Gh, 1K, *2U, 1Y.
1926	Grothans, Emma M.					1	2	2*WM.*	
1941	Gunter, M. A.					1	2	2*ATc.*	
1932	Haffelter, Hayes					1	1	1*Txl.*	
	Hagen, L.		1	1					1Tx.
1941	Haile, Clayton					1	1	1*JT.*	
1937	Halbert, Robert					1	1	1*Ta.*	
	Haliel, F.				1				
1937	Hall, Fred W.					1	1	1*Ta.*	
1872-1878	*Hall, Elihu	1594	10	65	52				2Bm, 4Cd, *9Fm, 8Gh, 6K, 8M, 4Po, 1Ph, *11U, 12Y.
1930	Hall, Eugene					1	3	3*Txl.*	
1916	Hall, E. M.					2	2	1*Ta*, 1*oL.*	
	Hall, J. M.				4				
1939	Halloran, A. F.					1	3	3*Ta.*	

TABLE 2 (Continued)

Texas collections†	Texas plant collectors	1 TCh	2 DI	3 TM	4 TFI	5 CI	6 THe	7—44	45—93
	Halstead, F.				1				
1933	Hamblin, Wayne		1	1		1	2	2*Txl.*	1Tx.
1923-1924	Hamby, Ellen Lindsey					1	211	211*BU.*	
1931	Hamilton, J. C.					1	1	1*TcW.*	
1928-1944	Hamilton, Viola				1	1	5	5*TcW.*	
	Hamlin, J. C.				1				
1940	Hanby, Mack					1	3	3*BU.*	
	Hanes, C. R.				1				
	Hanes, F.				1				
1931	Hanfield, (Mrs.) V. E.					1	1	1*Txl.*	
1941	Hankamer, Rubalee					1	9	9*BU.*	
1932	Hanna, Russell					1	1	1*Txl.*	
1919-1922	Hanson, Herbert Christian	3	5	33	22	1	41	41*Txl.*	*10Gh, 6M, *R, 11U, *6Y.
1894	Hapeman, Harry	9							
	Hardin, James		1	1		1	2	2*Txl.*	1Tx.
1929	Hargrove, Maurine					1	1	1*Txl.*	
1898	Harltmann, Carl					1	1	1*Txl.*	
	Harper, Roland				3				
1926-1938	Harris, Benjamin Bee	2	1	4	27	4	418	47*Txl*, 362*Ts*, 7*MeC*, 2*AR.*	*4U.
1933	Harris, Frank					1	1	1*Ta.*	
1932	Harris, Mary E.					1	2	2*Txl.*	
1934	Harris, Robert					1	1	1*TPh.*	
1933	Harrison, A. J.	3							
	Harrison, George John		2	19					*Gh, 19U.
1898	Harrison, W.					1	1	1*Ta.*	
1911-1926	Hartmann, Carl				1	3	11	9*Txl*, 1*WM*, 1*TPe.*	
1939	Harty,				1	2	10	7*Ts*, 3*MeC.*	
	Hastings, H. S.				5				
1881	Havard, Volery	403	3	21	36	1	1	1*AR*	*9Gh, 1Ph, *11U.
1927	Havens, Bessie					1	1	1*Txl.*	
	Hayden, A.				2				
1858-1859	*Hayes, (Dr.) Sutton	147	2	2	8				1Fm, 1Gh.
1933	Haynes, Naomi					1	1	1*Txl.*	
1931	Hays, Jack					1	1	1*Txl.*	
	Hays, S.				3				
1931	Hazl, Pauline Hogh					1	2	2*Txl.*	
1936-1937	Headlee, Ralph H.				1	3	15	1*Txl*, 2*Ta*, 12*Sc.*	
	Headley, F. B.				3				
1908-1909	Heald, F. DeForest					1	17	17*Txl.*	
1932	Heard, Lutie					1	1	1*Txl.*	
1921	Heddle, John R.	8							
	Hienze, D. B.				1				
1894-1898	Heller, Amos Arthur	382	13	86	31	2	2	1*Ta*, 18*M*	1Cb, 2Cl, 4Fm, 15Gh, 5K, 14M, 1Mc, 4Mn, 2Nd, 9Ph, 5R, 16U, 18Y.
1898	Heller, E. Gertrude	32			4	1	1	1*Ta.*	
1925	Hellman, L.					1	1	1*Txl.*	
1912	Hemington, Lizzie					1	2	2*Txl.*	
1927-1928	Henderson, J. B.					1	7	7*Txl.*	
1933-1936	Henderson, Leta					1	3	3*Txl.*	
1939	Hendrix, Ceora					2	6	5*Ts*, 1*MeC.*	
	Hendrix, E.				1				
1934	Henon, L. C.				1	1	2	2*Txl.*	
1935	Hensel, Rudolf					1	1	1*Ta.*	
1943	Hesse, Curtis J.					1	2	2*Ta.*	
1932	Hewatt, Willis					1	27	27*Ts.*	

TABLE 2 (Continued)

Texas collections†	Texas plant collectors	1 TCh	2 DI	3 TM	4 TFI	5 CI	6 THe	7—44	45—93
----------	Heyne, E. C.					1	1	1*Txl.*	
1931	Hicks, Doris					1	2	2*Txl.*	
----------	Hicks, V.				1				
1936-1941	Higdon, W. Dain					8	47	34*Txl*, 2*SM*, 1*HB*, 1*Tct*, 3*TPr*, 2*Tll*, 2*TM*, 2*Sw*.	
----------	Higgins, Zada					1	1	1*Txl.*	
----------	High, M. M.		1	2	3				2M.
1926	Hildebrand, Edith Fly					1	5	5*WM.*	
1936	Hildebrand, (Mrs.) W. J.	9			1	1	2	2*Ta.*	
1912	Hill, F. W.					1	1	1*Txl.*	
----------	Hill, Robert Thomas	1			2				
----------	Hillje, M.				1				
1943	Hilliard, J. B.					1	15	15*Tr.*	
----------	Hillman, M.					1	2	2*Txl.*	
1930-1942	Hinckley, L. C.	730	1	1	26	4	694	367*Txl*, 106*SM*, 1*TPk*, 220*Hi.*	1Fm.
1936	Hinds, Fay					1	1	1*ATc.*	
1936	Hinds, Francis					1	10	10*ATc.*	
1936	Hinds, J.					1	1	1*ATc.*	
1935	Hinojsa, Elodin					1	1	1*Txl.*	
1939	Hise, J. W., Jr.					1	1	1*Txl.*	
1903-1910	Hitchcock, Albert Spear	53				2	2	1*Txl*, 1*Ta.*	
----------	Hitchcock, C. Leo				1				
1927-1928	Hnatek, Margaret				1	1	5	5*Txl.*	
----------	Hobart,		1	1					1Gh.
----------	Hodge,				1				
1931	Hodges, F.					1	1	1*Txl.*	
1934	Hodges, Helen L.					1	1	1*Txl.*	
1937	Hodges, O. J.					1	3	3*BU.*	
1941	Hodges, R.					1	4	4*JT.*	
1902	Hodson, E. R.	1							
1932-1933	Hoffelter, H.					1	2	2*Txl.*	
----------	Hogan, G.		1	1					1U.
1930	Hoglund, Josephine					1	2	2*Txl.*	
1930-1931	Hoglund, (Mrs.) Pauline				5	1	40	40*Txl.*	
1943	Holley, Gene					1	1	1*HB.*	
----------	Holstein, George Wolfe		1	1					*1Ph.
1942	Holston, (Mrs.) J. L.					1	1	1*Ho.*	
1928	Holt, Joe					1	4	4*Txl.*	
1927-1928	Hooker, L. T.				1	1	2	2*Txl.*	
1928	Hookes, L. L.					1	2	2*Txl.*	
1932-1937	Hookes, J. L.				2	1	7	7*Txl.*	
1930-1940	Hookes, (Mrs.) J. L.		1	1	11	4	52	45*Txl*, 5*Sa*, 1*TPr*, 1*Dnh.*	1Tx.
1938	Hooser, Joyce					1	9	9*BU.*	
1926	Hope, Claude				1	1	1	1*Tt.*	
1939	Horsfall, Oliver					1	24	24*BU.*	
1939	Hotchkiss, N.					1	1	1*Txl.*	
1932	House, R. M.					1	2	2*Txl.*	
----------	Howard, Edgar Billings		1	1					*1Ph.
1936-1937	Howard, Marshall W.				1	3	19	2*Txl*, 1*Ta*, 16*Sc.*	
1931-1932	Howe, Mildred					1	2	2*Txl.*	
1932	Howe, Tharon					1	3	3*Txl.*	
----------	Howell, Arthur Holmes		2	3	8				*2U, 1Y.
1940	Hubbard, D.		1	1		1	1	1*Ta*	1Tx.
----------	Hubricht, Leslie				1				
----------	Hudgins, Joe					1	1	1*Txl.*	

TABLE 2 (Continued)

Texas collections†	Texas plant collectors	1 TCh	2 DI	3 TM	4 TFI	5 CI	6 THe	7—44	45—93
1941	Hughes, Alton					1	1	1*Txl.*	
1931	Hughes, F. B.					1	1	1*Txl.*	
1926	Hughes, (Mrs.) R. L.					1	1	1*WM.*	
1937	Hughes, R. W.		1	1		1	1	1*Ta*	1Y.
1933	Hughes, (Mrs.) W. R.				2	1	2	2*Dnk.*	
1938-1940	Hulme, Fred					1	7	7*BU.*	
1912	Huppertz, (Miss) J.					1	3	3*Txl.*	
1944	Hutcherson, Beth					1	1	1*HB.*	
1924-1925	Hynes, Mary Adelaide		1	1	12	3	137	135*Txl*, 1*Bg*, 1*TM*	1Tx.
1929	Ingram, Douglas C.		2	4	1				*3U, *1Va.
1938	Irick, M.					1	2	2*ATc.*	
1897	Irelean,		1	1					1M.
1925-1943	Isely, F. B.					1	22	22*Tr.*	
1929	Ivenson,					1	4	4*Txl.*	
1935	Jannson, Stella					1	2	2*Txl.*	
1937	Jenkins, Ross B.					1	1	1*Ta.*	
1890	Jennings, H. S.		1	1	8				1Mc.
1889	Jermy, Gustav	35	5	29	44				1Fm, 1Gh, *17M, 8U, 2Y.
	Jermy, Julius	1			6				
1932	Johanning, Douglas					1	2	2*Txl.*	
1930	Johnson, Annette				1	1	4	4*Txl.*	
1930-1931	Johnson, Francis					1	2	2*Txl.*	
	Johnson, F. W.				5				
1934	Johnson, James					1	2	2*Txl.*	
1930	Johnson, Juanita				2	1	10	10*Txl.*	
1929-1930	Johnson, J. L.				2	1	14	14*Txl.*	
	Johnson, J. S.		1	2					2Ph.
1886	Johnson, L. C.					1	3	3*Ta.*	
1931	Johnson, Lottie May					1	4	4*Txl.*	
1932	Johnson, Norma					1	4	4*Txl.*	
1932	Johnson, P. R.					2	2	1*Ta*, 1*Txal.*	
1933	Johnson, Vera Ellen					1	1	1*Txl.*	
1936	Johnston, J. R.					1	2	2*Tt.*	
1939	Jones, Betty				1	2	3	1*Ts*, 2*MeC.*	
1926	Jones, Ida S.	5			3	1	18	18*WM.*	
1882-1931	Jones, Marcus Eugene	179	13	49	113	3	7	3*Txl*, 1*Ta*, 3*SM*	1Ar, 1Bm, 3Cl, 4Cs, 1Dd, 3Fm, *9M, 13Po, 4Ph, 2R, 1Tx, *4U, 3Y.
	Jones, Mary E.					1	2	2*Txl.*	
1936	Jones, S. E.					1	1	1*Ta.*	
	Jones, Winell					1	1	1*Txl.*	
	Jones, Wyatt Wagner		2	3					*2Gh, 1Y.
1931	Jones, Yvonne		1	3	1	1	15	15*Txl*	3Tx.
1875-1884	Joor, Joseph F.	26	4	3	14				*Fm, *2Ls, *M, 1U.
1939	Jordan, Albert					1	3	3*Ts.*	
1887	Joyce, W. J.	1							
1927	Kallquist, C. R.				1				
1937	Keahey, Betty					1	8	8*BU.*	
1933	Kearney, Thomas Henry	3	1	16					16U.
	Kellerman, William Ashbrock.	1							
1930	Kelley, Agnes					2	2	1*Txl*, 1*Ahs.*	
1944	Kelley, Iva					1	1	1*Ts.*	
	Kellogg, J. H.				1				
1939-1941	Kellogg, W. H.					2	5	4*Txl*, 1*SM.*	
1935	Kelly, Frances					1	2	2*Tr.*	
1936	Kelly, Meda Lois					1	3	3*Tct.*	

TABLE 2 (Continued)

Texas collections†	Texas plant collectors	1 TCh	2 DI	3 TM	4 TFI	5 CI	6 THe	7—44	45—93
1926	Kendrick, J. I.					1	11	11*Tt.*	
1932	Kennedy, Madge					1	1	1*Txl.*	
1930-1932	Kenyon, (Mrs.) Frances					1	6	6*Ahs.*	
1930	Kerns, E.					1	1	1*Ahs.*	
1942	Kerns, Lynn					1	1	1*JT.*	
1898	Kerr,					1	1	1*Ta.*	
1931	Keyser, Ovan					1	2	2*Txl.*	
1926-1927	Killian, Oscar Leander		2	3	13	2	130	129*Txl*, 1*TPr*	*2Ph, 1U.
1937	King, Don					2	5	2*Ta*, 3*Sc.*	
1933	King, Hugh		1	1		1	7	7*Txl*	1Tx.
1934	King, Irene					1	4	4*Txl.*	
1930-1932	King, Lucile					1	4	4*Txl.*	
1937	King, Melissa					2	15	1*Txl*, 14*BU.*	
1932	Kirkpatrick, (Mrs.)					1	1	1*Txl.*	
1919-1935	Kirn, A. J.	4			7	2	49	3*Ta*, 46*WM.*	
1926	Kirtz, A. J.					1	1	1*Txl.*	
1932	Knight, Jack				1	1	1	1*Txl.*	
1928-1931	Knight, Marjorie					1	4	4*Txl.*	
1931	Knoblock, Margaret					1	6	6*Txl.*	
1903	Knolle, K. C.					1	3	3*Ta.*	
	Knowles, J.			1					
1934	Knox, Daniel R.					1	2	2*Txl.*	
1943	Koemel, Ella					1	1	1*Ahs.*	
1933	Kohfeldt, Kathleen				1	1	2	2*Txl.*	
	Kolthoff, I.			2					
1934	Korges, Bernice					1	2	2*Txl.*	
1932	Kram, B.					1	1	1*Txl.*	
1916	Krucker, Hedwig					1	1	1*Txl.*	
1920-1933	Kruger, Marvin				1	1	4	4*Txl.*	
	Kruger, Modena					1	1	1*Txl.*	
	Kruges,		1	1					1Tx.
1934	Kunckle, Alvin					1	2	2*Txl.*	
	Kuntze, C. E. O.				3				
	Kuntze, O.				3				
1899	Kyle, E. J.					1	8	8*Ta.*	
1937	Lace, W. R.					1	1	1*Ta.*	
1924	LaLonde, Virginia (Mrs. O. Sirey).					1	2	2*TcW.*	
1937-1938	Lamb, L. D.					2	6	2*Ta*, 4*McC.*	
	Lambert, B.				1				
	Lambert, J.				1				
1938-1939	LaMotte, Charles					1	2	2*Txl.*	
	Lands, H.				1				
1933	Lane, Louise		1	1		1	4	4*Txl*	1Tx.
	Langlois, A. B.				1				
	Langman, I. K.				1				
	Larrabee, Rollin North		1	1	1				*1U.
	Lea,		1	1					
	Leahy, F.				2				
1835	*Leavenworth, Melines Conklin.	1	2	3	1				*3Ph, *Y
	Leding,		1	1					1U.
1944	Lee, Addison					1	1	1*Ahs.*	
1936	Lee, Robert					1	1	1*Ta.*	
1939	Lehman, C. L.					1	5	5*Ta.*	
1934-1939	Lehman, V.				15	5	78	72*Txl*, 2*TPr*, 1*Sw*, 1*Tll*, 2*TM.*	
1930	Lehada, J.					1	1	1*Txl.*	

TABLE 2 (Continued)

Texas collections†	Texas plant collectors	1 TCh	2 DI	3 TM	4 TFI	5 CI	6 THe	7—44	45—93
1881-1882	Lemmon, John Gill		9						
1935-1941	LeSueur, Harde				1	4	32	29*Txl*, 1*SM*, 1*Tt*, 1*TPe*.	
1880-1894	Letterman, George Washington.	90	4	14	19	2	12	11*Txl*, 1*AR*.	
1934	Lewis, Elizabeth					1	3	3*Txl*.	
1935	Lewis, Helen N.					1	1	1*Tt*.	
1914-1918	Lewis, Isaac M.				2	1	5	5*Txl*.	
1939	Lewis, Marie					2	16	11*Ts*, 5*MeC*.	
1907	Lewton, Frederick Lewis	1	1	3	6				*3U.
1848-1874	**Lincecum, (Dr.) Gideon				1				
1849-1851	**Lindheimer, Ferdinand Jacob.	827	14	136	157	2	156	121*Txl*, 35*BU*	3Ar, 4Ca, 3Cd, 1Cl, 7Fm, 16Gh, 7K, *52M, 5Ok, 6Ph, 7Tx, 13U, 8Y, 4Pe.
1843	Lindley,				1				
1924	Lipscomb, Jane					1	1	1*TcW*.	
1898	Lishney, A.					1	1	1*Txl*.	
1934-1935	Little, V. A.					2	5	1*Ta*, 4*Tt*.	
1942	Livingston, P. S.					1	1	1*Ta*.	
1890	Lloyd, William M.	3							
1931	Llyrock, Henry					1	2	2*Txl*.	
1930	Loglum, Pauline					1	1	1*Txl*.	
	Long, Grace					1	1	1*Txl*.	
1900-1901	Long, W. H.	34				1	2	2*Ts*.	
1900-1901	Long, William Henry, Jr.	30	1	1	7	1	21	21*Txl*	1Tx.
	Longnecker, W. M.				3				
1938	Loomis, J. A.	3							
1929	Lowry, James H.					1	1	1*TcW*.	
1939	Loy, D. W.					1	1	1*Txl*.	
1937-1940	Lundell, Amelia A.				132	2	291	1*Txl*, 290*SM*.	
1932-1942	Lundell, C. L.	7			228	3	297	1*Txl*, 2*Ts*, 294*SM*.	
	Lynch, H.				1				
1939	Lynch, W. D.					1	2	2*Ta*.	
	Lynch, (Mrs.) W. D.				2				
1934	Maca, Joe					1	4	4*Txl*.	
	MacGarland, J.				1				
1910-1913	Mackensen, Bernard	121	2	4	13	1	15	15*WM*	2Fm, 2Mc.
	Mackenson, G.				1				
	Mackenzie, Kenneth Kent		6	5	3				*1w, *1M, 1Ph, 1U, *2Y.
1934	Maeyers, Pauline					1	1	1*Txl*.	
	Mahon, R.		1	1					1Ph.
1933	Mahoney, H.				1	1	9	9*Txl*.	
1937	Malone, Lucille					1	1	1*BU*.	
1938	Malone, M. S.					1	15	15*Ta*.	
	Manigualt, E. M.					1	2	2*Txl*.	
1852	Marcy,				1				
1932	Marlowe, Ward					1	1	1*Txl*.	
1934	Marr, J.					1	2	2*Tt*.	
1930	Marrs, (Mrs.) Della		1	1	1	1	9	9*Txl*	1Tx.
1937-1940	Marsh, Ernest G., Jr.	585			1	1	7	7*Txl*.	
1940	Marsh, J. F.					1	1	1*Txl*.	
1940	Marsh, G. E., Jr.					1	3	3*Txl*.	
1940	Marshall, Doyle					1	3	3.4*Tc*.	
1927-1928	Martin, Bernice					1	9	9*Txl*.	
1898	Martin, B.		3	3	1	1	1	1*Ta*	1Ph, 1Tx, 1U.
1938	Martin, (Mrs.) E.					1	2	2*Ta*.	

TABLE 2 (Continued)

Texas collections†	Texas plant collectors	1 TCh	2 DI	3 TM	4 TFI	5 CI	6 THe	7—44	45—93
----------	Martindale, Bob	----	----	----	----	1	1	1*Txl.*	
1930	Mascot, Grover J.	----	----	----	----	1	1	1*Txl.*	
1929	Mast, (Mrs.) A. J.	----	----	----	----	1	2	2*WM.*	
1939	Mathews, Eric	----	----	----	2	1	2	2*Ta.*	
1934	Mathews, Frederick Patrick.	----	----	----	----	1	3	3*Ta.*	
1939	Mathews, (Mrs.) F. P.	----	----	----	----	1	3	3*Ta.*	
1938	Mathews, Mary	----	----	----	----	1	3	3*ATc.*	
----------	Matthes, B.	----	----	----	2	----	----		
1942	Matthew, Ruth	----	----	----	----	1	11	11*ATc.*	
1933	Matthews, Lois	----	----	----	----	1	4	4*Txl.*	
1914	Matthews, S. C.	1	----	----	----	----	----		
1932	Mattlock, Joyce	----	----	----	1	1	2	2*Txl.*	
1940	Mauermann, R.	----	----	----	----	2	8	6*Txl*, 2*TPe.*	
1940-1941	Mauldin, Mildred	----	----	----	1	----	----		
1941	Mauldin, R.	----	----	----	----	1	1	1*Ta.*	
1934	May, Clarence	----	----	----	----	1	2	2*Txl.*	
1925-1926	May, G. Y.	----	----	----	----	1	9	9*WM.*	
----------	May, H. Y.	----	----	----	2	----	----		
----------	Maxon, William Ralph	----	1	----	1	----	----	----------	*U.
1893	Maxwell, C. F.	69	1	1	----	----	----	----------	1Fm.
1919-1925	McAllister, F.	----	----	----	----	2	12	11*Txl*, 1*TPe.*	
1931-1939	McBryde, James B.	----	2	7	10	6	211	102*Txl*, 81*Ts* 25*McC*, 1*TcW*, 1*TPe*, 1*SW.*	1R, *6Txa.
1932	McCain, Jacqueline	----	----	----	----	1	1	1*Txl.*	
1932	McCain, Lillian	----	----	----	----	1	4	4*Txl.*	
1938	McCameron, Lloyd	----	----	----	----	1	7	7*ATc.*	
1934-1939	McCart, William Larrey	----	----	----	17	5	502	25*Txl*, 2*Ta*, 154*Ts*, 320*McC*, 1*TPe.*	
1881-1882	McCarthy, Gerald	4	----	----	----	----	----		
1880-1887	McCarthy, S.	----	----	----	----	1	2	2*Th.*	
1931	McCaskill, D. A.	----	----	----	----	1	1	1*Txi.*	
1928	McClellan, Sybil	----	----	----	----	1	4	4*BU.*	
1922-1926	McClung, Esthur	----	----	----	7	1	45	45*Txl.*	
1934	McClung, June	----	----	----	----	1	2	2*Txl.*	
1938	McClure, Lena M.	----	----	----	1	2	5	4*Ts*, 1*McC.*	
1931	McConal, Aline	----	----	----	----	1	2	2*Txl.*	
----------	McConal, Louise	----	----	----	----	1	1	1*Txl.*	
1942	McCormick, Ruth	----	----	----	----	1	1	1*Ho.*	
1927	McCoy, Ed.	----	----	----	----	1	1	1*Txl.*	
1932	McCoy, Elva	----	----	----	----	1	4	4*Txl.*	
1934	McCoy, Evelyn	----	----	----	----	1	1	1*Txl.*	
1938-1939	McDaniel, C.	----	----	----	2	2	15	9*Ts*, 6*McC.*	
1931	McDaniel, Freddie Mae	----	----	----	----	1	3	3*Txl.*	
1931-1934	McDaniel, Helen L.	----	----	----	----	2	2	1*Txl*, 1*Tt.*	
1920	McDavid, Laureame	----	----	----	----	1	5	5*TcW.*	
1935	McDougall, W. B.	----	----	----	----	1	3	3*Txl.*	
1942	McFadden, E. S.	----	----	----	----	1	2	2*Ta.*	
1931	McFarland, James B.	----	----	----	----	1	4	4*Txl.*	
1933	McGarland, Jimmie Mae	----	----	----	----	1	1	1*Txl.*	
1941-1942	McGinnis, Ozette (Mrs. Waldrop).	----	----	----	1	1	10	10*Txl.*	
1927-1933	McGregor, Alice	----	1	1	----	1	1	1*Txl*----------	1M.
----------	McGregor, J. L.	----	----	----	1	----	----		
1933	McGuire, Elizabeth	----	----	----	----	1	2	2*Txl.*	
1939	McHenry, Billie	----	----	----	----	1	1	1*Tet.*	
1931	McKavitt,	----	----	----	----	1	1	1*Txl.*	

TABLE 2 (Continued)

Texas collections†	Texas plant collectors	1 TCh	2 DI	3 TM	4 TFI	5 CI	6 THe	7—44	45—93
1911-1928	McKee, Lena				3	4	27	23*Txl*, 1*Ts*, 1*SM*, 2*TPv*.	
	McKelvey, Susan Adams (Delano).		2	5	15				*Ah, *5Ph.
	McKenzie, K. K.				1				
1936-1937	McLaughlin, J. Ross					3	4	1*Txl*, 1*Ta*, 2*Sc*.	
1944	McLeod, Claude					1	1	1*SRW*.	
1939	McMahon, Robert					1	1	1*TPh*.	
1932	McManus, Iva Mae					1	1	1*Txl*.	
1930	McMeans, Wycke					1	1	1*Txl*.	
1933	McMennamy, James					1	1	1*Txl*.	
1925	McMillan,					1	1	1*WM*.	
1917-1937	McMullen, E.		2	9	11	6	98	74*Txl*, 19*Ts*, 2*TPv*, 1*Sw*, 1*TM*, 1*Tll*.	
1939	McPhail, L. R.					1	6	6*ATc*.	
1929	McWhorter, Opal				1				
	McWhorton, Sam					1	2	2*Txl*.	
	McWilliams, A. E.				3				
1912-1917	McWilliams, (Mrs.) A. E.					1	7	7*Txl*.	
1907	Meade, Rowland Montgomery.	1							
1893	Mearns, E. A.		1	4	10				4U.
1926	Mebane, Sallie B.	1			3	1	13	13*WM*.	
	Medford, Hall					1	1	1*Ta*.	
1920	Medley, Arnold					1	1	1*WM*.	
1939	Medley, Oscar					2	5	4*Txl*, 1*Hi*.	
1932	Melton, Norman					1	1	1*Txl*.	
1930	Mendias, Lucille					1	1	1*Txl*.	
1851	Menzel, M. T. G.		1	1					1B.
1931	Mercer, Edward					1	4	4*Txl*.	
1913	Mercer, Ivor Wood					1	2	2*Txl*.	
1931	Mercer, W. L.				1	1	1	1*Txl*.	
	Merrill, Frederick James Hamilton.		1	2	1				*2Y.
1935	Metcalfe, T. P.		5	5	1	1	1	1*Ta*	1Ar, 1Gh, 1M, 1U, 1Y.
1930-1933	Metz, (Sister) Mary Clare		2	7	27	1	168	168*ol*.	6Ca, 1Y.
1922	Meuere, E.		1	1	1				1Cs.
	Meyer, E.				3				
1942	Meyer, Mary Densmoor					1	2	2*Ho*.	
1939	Miles, Juanita					2	3	1*Ts*, 2*McC*.	
1933-1935	Miller, Estelle					1	6	6*Txl*.	
1940	Miller, Katherine					1	1	1*HB*.	
1937	Miller, L.					1	1	1*Tt*.	
1934-1942	Miller, Margaret					2	2	1*Txl*, 1*Ho*.	
1931	Miller, Ray					1	6	6*WM*.	
1896	Milligan, J. M.				3				
1887-1897	Milligan, (Mrs.) J. M.	25	1	1					1U.
1941	Mills, Franklin					1	3	3*BU*.	
1933	Mitcham, Merlin Lee				2	1	7	7*Txl*.	
1933	Mitchell, Louis					1	1	1*Txl*.	
1933	Mitchial, M. L.					1	1	1*Txl*.	
1935	Moebus, Pearl					1	1	1*Txl*.	
1944	Moehr, Dorothy				1	1	1	1*Ahs*.	
1906	Moffatt, William Sawder	9							
1880-1887	Mohr, Carl Theodor	4							
1927-1930	Molby, Ethel E.				7	2	138	14*Txl*, 124*Bg*.	
1932	Moldenke, Harold N.		1	1	5				1Y.
1941	Moon, Brunelle					1	1	1*JT*.	

TABLE 2 (Continued)

Texas collections†	Texas plant collectors	1 TCh	2 DI	3 TM	4 TFI	5 CI	6 THe	7—44	45—93
1929	Moore, E.					1	2	2*Txl.*	
1938	Moore, E. M.				1	1	3	3*Tx.*	
1934	Moore, James					1	2	2*Txl.*	
1931	Moore, John Adam		8	15	11				1**Cl**, 1**Cs**, 1**Dd**, 6**M**, 1**Mc**, 1**Mn**, 2**Ph**, 2**Y**.
1941	Moore, Marilyn					1	7	7*ATc.*	
	Moore, Y.					1	1	1*Txl.*	
1937	Moosberg, Carl A.					1	2	2*Tt.*	
1930	Morgan, Aucle					1	3	3*Txl.*	
	Morgan, F.					1	2	2*Txl.*	
1919	Morgan, Mattie Beth					1	9	9*TcW.*	
	Morris, R. B.					1	1	1*Txl.*	
1928-1935	Morrow, Marie B.				3	3	23	21*Txl*, 1*Tt*, 1*TPv.*	
	Morton, C. V.				1				
1937	Mosher, Opal					1	1	1*BU.*	
1941	Mosely, Doris					1	4	4*Ho.*	
1933	Mosley, Elsie					1	1	1*Txl.*	
	Moyer, L. R.				1				
1929	Mueller, O.	12			2	1	19	19*WM.*	
1930	Mulholland, L. E.					1	9	9*WM.*	
1929-1933	Mu(e)ller, C. H.	299	5	13	24	10	205	152*Txl*, 58*M*, 37*Tt*, 1*Bg*, 1*Ho*, 1*HB*, 1*Tct*, 1*Tll*, 3*TPv*, 2*TM*, 1*Sw.*	1**Gh**, 4**M**, 2**Mc**, 1**Ph**, 3**Tx**, 2**Y**.
	Mulford,		2	6					3**M**, 3**Y**.
1931	Mulloy, N. T.					1	3	3*Txal.*	
1893	*Munson, Thomas Volney	2	1	1					1**M**.
1935	Munz, Philip Alexander	2	2	5	21				*1**Co**, 4**Po**.
1926-1930	Muske, (Mrs.) J. C.					1	15	15*Txl.*	
1941	Murray, Ellen					1	9	9*BU.*	
1925-1928	Murray, Leo T.	21				3	10	1*Txl*, 7*Tt*, 2*TR.*	
1939	Nash, Elizabeth				1	2	13	5*Ts*, 8*McC.*	
	Nealey, C. S.				3				
1882-1894	Nealley, George C.	771	6	16	32	4	77	17*Txl*, 54*Ta*, 1*Th*, 5*AR*	1**Dd**, 1**De**, 4**Fm**, 3**Gh**, *6**U**, 1**Y**.
1938	Neel, Ruby R.					1	1	1*BU.*	
1930-1931	Neiley. Egbert					1	7	7*Txl.*	
1942	Nelson, Aven				1				
1941-1942	Nelson, (Mrs.)Allie Fish				1	1	57	57*Txl.*	
1938	Nelson, Irwin					1	12	12*TR.*	
1934	Nelson, Louise					1	1	1*Tt.*	
1898-1926	Ness, H.				29	1	179	179*Ta.*	
	Newhall, S.				1				
1936	Newman, Coleman				1	1	5	5*TR.*	
1939	Newton, V.				2	2	7	5*Ts*, 2*McC.*	
1934	Nichols, Claude R.					1	1	1*Tr.*	
1940	Nicholson, A. J.					1	6	6*Txl.*	
1893	Nickels, (Mrs.) Anna Buck	4			1				
1929-1930	Normand, Emma		1	1	1	1	19	19*Txl*	1**Tx**.
1927-1929	Normand, J. Frank				7	2	83	82*Txl*, 1*Sw.*	
1931	Norton, B.				1	1	6	6*Txl.*	
1932	Norwood, Robert W.				1				
1915-1917	Norwood, W. H					1	2	2*Txl.*	
1834	Nuttall, Thomas	1							
1901	Oatman, H. W.					1	1	1*Txl.*	
1900-1901	Oberholzer, H. C.		1	1	1	1	2	2*Txl.*	1**Tx**.
1931	Ogle, J. D.	1							
1934	Olguin, Margarite					1	6	6*Txl.*	

TABLE 2 (Continued)

Texas collections†	Texas plant collectors	1 TCh	2 DI	3 TM	4 TFI	5 CI	6 THe	7—44	45—93
1917	Olive, E. W.					1	1	1*Txl.*	
1941	Orchard, C. D.					1	1	1*Txl.*	
1913	Orcutt, Charles Russell	5	2	6	16				*5M, 1U.
1932	Orr, (Mrs.) W. S.					1	11	11*Txl.*	
.....	Osterhout, G.				1				
1938	Ownbey, Marion				1	1	3	3*Txl.*	
1938	Ownbey, Ruth Peck				1	1	3	3*Txl.*	
1939-1941	Owens, E. F.					2	13	1*Txl*, 12*Ta.*	
1941	Owens, H.					1	3	3*ATe.*	
1931	Ownsbey, Mary Elizabeth					1	2	2*Txl.*	
1883-1884	Oyster, John Houk	14							
1942	Ozette, (Mrs.)				3	1	1	1*Txl.*	
1904-1925	Pace, (Miss) Lulu	1	1	3	2	2	37	1*Txl*, 36*BU*	*3M.
1942	Paden, Jean					1	8	8*Ho.*	
1926	Pagel, Lydia E.	1			3	1	9	9*WM.*	
1943	Painter, Joseph T.					1	1	1*Txl.*	
1922-1924	Painter, R. H.	6			6	2	43	41*Txl*, 2*TPe.*	
1880	Palmer, Edward	34	6	10	4	1	1	1*SM*	*3Gh, 2K, *2M, 1Ph, *2U, *Y.
1918-1929	Palmer, Ernest Jesse	159	14	237	232	4	132	128*Txl*, 1*SM*, 1*AR*, 2*TPe.*	*4Ah, 4Cl, 9Cs, 2Dd, 1Fm, 3Gh, 3K, *139M, 1O, 34Ph, 1R, 1Tx, *M, 1Tx, 16U, 18Y.
.....	Pammel, C. L.				1				
1888-1889	Pammel, Louis Hermann	5	2		16				*Iw, *M.
1907	Parish, Samuel Bonsall	1				1	1	1*Txl.*	
1912	Parker, Clara M.				6	1	8	8*Txl.*	
1930-1944	Parks, H. B.	1	1	5	135	7	376	3*Txl*,339*Ta*,19*WM*, 5*Sa*, 8*ATe*, 1*Tll*, 1*TM.*	5M.
1929-1942	Parks, Hal B., Jr.	124			2	3	156	19*Ta*, 98*WM*, 39*ATe.*	
1930-1932	Parks, Inez		1	1		1	25	25*Txl*	1Tx.
1937	Parks, Mabel				1	1	2	2*Ta.*	
1850-1867	*Parry, (Dr.) Charles Christopher.		3	2	7	1	1	1*Ta*	1Gh, *M, 1U.
1939	Paschall, Juanita					2	18	5*Ts*, 13*MeC.*	
1941	Patrick, Harry					1	2	2*Sw.*	
1930	Peckam, Thelma		1	1	1	1	9	9*Txl*	1Tx.
1936	Pellett, F. C.					1	3	3*Ta.*	
1936	Penfound, W. T.				1	1	9	9*Txl.*	
1920	Pennell, Francis Whittier	26	16	269	23	1	3	3*Txl*	5Cm, 1Dd, 24Fm, 1Ill, 12K, 19L, 27M, 4Nd, 40, *32Ph, 4S, 2T, 28Tx, 31U, *59Y, *36Pe.
.....	Perkins, A. E.				4				
1930	Perkins, R. L.					1	4	4*Txl.*	
1937	Perrin, John A.					2	8	1*Ta*, 7*Sc.*	
1938	Peterson, (Mrs.) Lenns					1	2	2*Ta.*	
1931	Peterson, Reba					1	2	2*Txl.*	
1938	Peyton, Ben					1	3	3*TR.*	
.....	Philipps, (Mrs.) J. I.		1	1					1Tx.
1939	Phillips, E.					2	9	5*Ts*, 4*MeC.*	
1931	Phillips, T. I. F.					1	1	1*Txl.*	
1877	Phippen, George Dean	35							
.....	Phipps, J. F.				1				
1931	Phipps, (Mrs.) J. F.					1	12	12*Txl.*	
1935	Pichal, Mary					1	2	2*Txl.*	

TABLE 2 (Continued)

Texas collections†	Texas plant collectors	1 TCh	2 DI	3 TM	4 TFI	5 CI	6 THe	7—44	45—93
1936	Pickenbough, (Mrs.)				1				
1929	Pierson, F. W.					1	1	1*Txl.*	
	Pillard, A. S.				1				
1922	Pilsbry, Henry Augustus		1	11	1				*11Ph.
1833	*Pitcher, (Dr.) Zina		1	1					1Y.
1893-1895	Plank, Elisha Newton		2	2	9				*M, *2Y.
1943	Poland, Violet					1	4	4*Tr.*	
1943	Pollard, Annie Lou					1	1	1*Ahs.*	
1933	Polson, Lillian					1	2	2*Txl.*	
1933	Polson, Mary Evan					1	4	4*Txl.*	
	Pope, Gerald					1	2	2*Txl.*	
	Pope, (Capt.) John	58							
1931	Porter, Hazel					1	9	9*Txl.*	
1856	Porter, Thomas Conrad	22			2				
1943	Porterfield, Hugh G.					1	1	1*Sc.*	
1939	Posey, S.				1	2	13	10*Ts*, 3*McC.*	
1940	Potss, R. C.					1	1	1*Ta.*	
1923	Potts, Pauline					1	3	3*Txl.*	
1935	Potts, R.					1	1	1*Txl.*	
1930-1934	Powers, Luther		1	1		2	13	9*Ta*, 4*Txal*	1Txa.
1940	P'Pool, M.					1	2	2*ATc.*	
1893	Pratt, Alice D.	1							
1911	Pratt, O. A.					1	1	1*Txl.*	
1933	Price, Harold					1	2	2*Txl.*	
1894	Price, R. H.					1	1	1*Ta.*	
1943	Pridgeon, F. O.					1	1	1*SG.*	
1883-1889	Pringle, Cyrus Guernsey	60	9	8					1Fm, 1Gh, 1K, 1M, 1Nd, 1Ph, *1U, 1Y, *Ve.
1924	Prouty, B. W.					1	2	2*TcW.*	
1934	Pryor, Ruby					1	1	1*Txl.*	
	Purcell, G.				2				
1934	Purcell, Graham, Jr.					1	3	3*Txl.*	
1932	Purdue, Neil				2	1	5	5*Txl.*	
	Purpus, C. A.		2	3	1				2Cl, 1Fm.
1939	Pursley, Mary M.					1	1	1*Txl.*	
1924-1931	Quillen, Roy W.	3				1	9	9*WM.*	
	Raborn,				1				
1893	Ragsdale, G. H.	5							
	Raimey, J. R.					1	3	3*Ta.*	
1935	Raitsch, Emma					1	1	1*Txl.*	
1939	Ramsey, Rosa Lee					1	7	7*ATc.*	
1900	Ramsey,				1	1	4	4*Txl.*	
1869	*Ravenel, Henry William	1			3				
1931	Rayborn,					1	4	4*Txl.*	
	Reagan, A. B.		1	1					1Tx.
1930-1931	Rechinthin, Eva (Mrs. Blaseke).					1	24	24*oL.*	
	Reed, Clyde Theodore		2	3	2				*1Ph, *2Tx.
1927-1939	Reed, Edward Looman		1	1	14	3	401	26*Txl*, 374*Tt*, 1*TPr.*	
1925	Reed, E. T.					1	4	4*AR.*	
1936-1937	Reed, H. R.				2	1	2	2*Ta.*	
1932	Reed, K. B.		1	1	1	1	1	1*Txl*	1Tx.
1937	Reed, Louise					1	1	1*McC.*	
1932	Reese, Miller					1	1	1*Txl.*	
1938-1944	Reeves, Robert G.				52	1	364	364*Ta.*	
1941	Reeves, (Mrs.) R. G.					1	1	1*Ta.*	
1935	Rehm, Jane					1	2	2*Tt.*	
1902	Rehn, James Abram Garfield.		1	1					1Ph.

TABLE 2 (Continued)

Texas collections†	Texas plant collectors	1 TCh	2 DI	3 TM	4 TFI	5 CI	6 THe	7—44	45—93
1929	Reid, (Mrs.) Bruce M.	1			4				
1930	Rendon, John					1	1	1*Txl.*	
----------	Rendor, J.				1				
----------	Renfro, Odorine					1	1	1*Txl.*	
1930-1932	Rettig, Martha B.					1	11	11*Tr.*	
1856-1903	**Reverchon, Julian	2494	16	171	190	3	41	2*Txl*, 38*Ta*, 1*SM*	**1Ah, 1B, 10Fm, 20Gh, 2K, *81M, 1Mc, 1Mn, 2Nd, 1Or, 1Po, 4Ph, 26U, 12Y, 1Yl, 7Pe.**
1931	Reynolds,				1	1	4	4*Txl.*	
1929	Rhodes, Effie Mae					1	2	2*Txl.*	
1941	Riby, Bill					1	1	1*Txl.*	
1899	Riby, Margaret					1	2	2*Th.*	
1935	Rice, S.					1	1	1*Txl.*	
1933	Richardson, Clarence				1	2	5	1*Txl*, 4*ATc.*	
1920	Richardson, Mary Lou					1	2	2*TcW.*	
1917	Richardson, W.					1	1	1*Txl.*	
----------	Ricker, Percy Leroy		1	1					*1U.
1923	Richter, Leilet				3	1	13	13*Txl.*	
1941-1942	Reidell, Marguerite Meta				1	1	71	71*Txl.*	
----------	Riedel, (Mrs.)					1	2	2*Txl.*	
1939	Riefagel, R.					1	2	2*Txl.*	
1931	Riensky, V.					1	1	1*Txl.*	
1941	Riby, Bill					1	1	1*Txl.*	
1941	Riley, Bill					1	1	1*JT.*	
1930	Rinisky, V.					1	1	1*Txl.*	
----------	Risinger, J.					1	1	1*Txl.*	
1939	Robbins, Garnette					1	12	12*BU.*	
1938	Robbins, Ida					1	1	1*BU.*	
1931	Roberts, Frances					2	2	1*Txl*, 1*BU.*	
1910	Roberts,					1	5	5*Txl.*	
1940	Robertson, Lint					1	9	9*Ta.*	
1940	Robinson, E. R.	3			1				
----------	Robinson, George					1	1	1*Txl.*	
1939	Robinson, Robert					1	1	1*Sw.*	
1926-1931	Robinson, (Mrs.)				2	1	11	11*Txl.*	
1898	Robson,					1	1	1*Ta.*	
1939	Rodger, Fay					1	9	9*ATc.*	
1845-1847	**Roemer, (Karl) Ferdinand von.		2	1					*B, 1Cs.
1933	Rogers, C. H.					1	2	2*Ta.*	
1939	Rogers, Hope				1	2	14	6*Ts*, 8*MeC.*	
----------	Rollins, Reed C.				1				
1940-1941	Rosberg, David W.					1	2	2*Txl.*	
1897-1913	Rose, Joseph Nelson	2	6	14	5				*1Fm, 1Gh, 2M, 1Ph, *5U, 4Y.
1941	Rose-Innes, Reginald				1	1	1	1*JT.*	
----------	Royden, T. H.					1	1	1*Txal.*	
1918	Ruckes, Herbert					1	1	1*Ta.*	
1935	Rudi, Evelyn					1	1	1*Txl.*	
1877-1878	Rugel, Ferdinand	5			2				
1922-1943	Runyon, Robert	148	2	8	125	5	294	65*Txl*, 1*Ts*, 1*SM*, 226*RR*, 1*Ho.*	2Ph, *6U.
1910	Rusby, H. H.				1				
1923	Russell, E. E.	3	2	2	1	3	25	23*Txl*, 1*TM*, 1*TPe*	1T, 1V.
1903	Russell, M.					1	2	2*Ta.*	
1927	Russell, Paul George	1			3				

TABLE 2 (Continued)

Texas collections†	Texas plant collectors	1 TCh	2 DI	3 TM	4 TFI	5 CI	6 THe	7—44	45—93
1909-1931	Ruth, Albert	884	10	49	52	8	475	71*Txl*, 59*Ts*, 109*SM*, 5*MeC*, 31*BU*, 127*AR*, 72*TeW*, 1*TPr*.	**2Cm, 6Fm,** *4Gh,*8M, **2Mc, 2Mn,** 11**Ph,***13U, *12**Y, 2Pe.**
1923	Ruth, E. C.					1	1	1*Ta*.	
1939	Sanders, A.					2	11	8*Ts*, 3*MeC*.	
1942	Sanders, Jack M.					1	2	2*Ta*.	
1939-1942	Sanders, Ottys				16	1	27	27*SM*.	
1939	Sanders, Ruth				3	1	2	2*SM*.	
1928	Sands, Edna					1	1	1*Txl*.	
1885-1913	Sargent, C. S.				1				
	Sartwell, H. P.				1				
1939	Satterfield, Inez				2	3	22	2*Txl*, 9*Ts*, 11*MeC*.	
1896-1898	Saunders, DeAlton	2							
1933	Savage, Mae LaVerne					1	5	5*Txl*.	
1933	Savage, Margaret					1	1	1*Txl*.	
1933	Sawder, Joe				1	1	1	1*Txl*.	
1926	Schattenberg, H. C.					1	8	8*WM*.	
1892-1896	Schaupp, F. G.	32							
1934-1938	Schleusse, L. W.					2	32	26*Txl*, 6*TPh*.	
1853-1873	*Schlottmann, (Dr.) Adolphus.				3				
1934	Schmidt, Chick					1	1	1*Txl*.	
1935	Schmidt, D. R.					1	1	1*Txal*.	
1934-1938	Schmidt, H.					1	2	2*Ta*.	
1942	Schmidt, Robert					1	1	1*Ho*.	
1894	Schneck, Jacob	80			2				
	Scholt, G.				1				
1930	Scholz, Barbara (Mrs. Beason).					1	6	6*oL*.	
	Schoop, C.				1				
1910	Schostag, Emil Ludwi					1	6	6*Txl*.	
1851-1853	*Schott, Arthur (Carl Victor).	16	3	8	17				*2**Fm, 1U, 5Y.**
	Schott, G.					1	1	1*Txl*.	
1931	Schultz, Glen					1	2	2*Txl*.	
1917-1939	Schulz, Ellen Dorothy (Mrs. Quillen).	247	6	15	115	4	585	28*Txl*, 540*WM*, 16*BU*, 1*TPr*.	**1Cb, 2Fm,** 2**Mc,** 1**Po, 1Ph,** *8**U.**
	Scottsberg, J. F.					1	1	1*Txl*.	
1930	Seguna, Mary					1	1	1*Txl*.	
	Seler, G. E.				1				
1931	Sellers, Veseva		1	1		1	2	2*Txl*.	**1Tx.**
1939	Shackelford, S.				1	2	10	3*Ts*, 7*MeC*.	
1930	Shannon, Rena Lee					1	4	4*Txl*.	
1940	Shargel, Helen					1	2	2*Ho*.	
1931	Shaw, Elouise					2	8	7*Txl*, 1*SM*.	
1932	Shaw, L.					1	2	2*Txl*.	
1899-1904	Shear, Cornelius Lott	2							
1924	Shelton, J.					1	2	2*TeW*.	
1884	Shelton, P. L.	1							
1934	Shepard, (Mrs.) Myrtle					1	11	11*Txl*.	
1901	Shepherd, M.		1	1	3				**1U.**
1931	Sherian, Dale					1	4	4*Txl*.	
	Shiller, A.				1				
1931	Shiller, Ethelyn					1	1	1*Txl*.	
1941-1942	Shiller, Ivan					1	118	118*Ta*.	
1939	Shoemaker, R.					1	1	1*Tet*.	
1940	Shreve, Forrest				3	1	1	1*SM*.	

TABLE 2 (Continued)

Texas collections†	Texas plant collectors	1 TCh	2 DI	3 TM	4 TFI	5 CI	6 THe	7—44	45—93
1931	Shultz, James					1	1	1*Txl.*	
1931	Shultz, Junior					1	1	1*Txl.*	
1939	Sides, Vilma				1	1	5	5*Ts.*	
	Sieger, J.					1	2	2*Txl.*	
1939-1940	Siegler, H. R.					1	3	3*Txl.*	
1939	Silbey, J. K. G.					1	1	1*Ts.*	
1930-1941	Silveus, W. A.	3				5	349	7*Txl*, 18*M*, 325*SG*, 14*ol.*, 2*TPr.*	
1891	Simonds, Frederick W.	2				2	6	5*Txl*, 1*McC.*	
1898	Simpson, J. H.					1	1	1*Ta.*	
1927-1943	Sinclair, John F.					2	196	111*Txl*, 85*Si.*	
1940	Singleton, Robert					1	13	13*Ta.*	
1942	Sitton, L.					1	1	1*Tc.*	
	Skottsberg, C. J. F.				6				
	Slater, (Mrs. H. D.) Elsie McElroy.				1				
	Slavin, B. H.				1				
1933	Sliger, Ruby					1	1	1*Txl.*	
1930	Sloan, Billie Louise					1	3	3*Txl.*	
1895	Small, John Kunkel		2	5	12	1	1	1*Tt.*	*Fm, *5Y.
	Smith, Beaulah		1	1	1				1U.
1931	Smith, Bob					1	1	1*Txl.*	
1934	Smith, Charles (Chuck)					2	5	1*Txl*, 4*Tt.*	
1898	Smith, F. E.					1	2	2*Txl.*	
1929	Smith, Genevieve	1							
1935	Smith, Hugh B.					1	3	3*JT.*	
1936	Smith, H. E.					1	1	1*Ta.*	
1930	Smith, (Mrs.) H. K.					1	1	1*Txl.*	
1923	Smith, Irma (Mrs. Schmidtzinki).					1	1	1*TPh.*	
1931	Smith, John					1	23	23*Txl.*	
1930	Smith, J. E.					1	1	1*Txl.*	
	Smith, J. G.				1				
1935	Smith, Kendrick E.				4	1	34	34*Txl.*	
1940	Smith, L. A.					1	10	10*Ta.*	
1920	Smith, Olive					1	2	2*TcW.*	
1930	Smith, Silas					1	1	1*Txl.*	
1923	Smith, Stanley E.					1	1	1*SM.*	
1888	Smith, Sydney Irving	1							
1935	Smith, (Mrs.) Stuart P.					1	7	7*Txl.*	
	Smith, (Mrs.) S. R.				4				
1933	Smith, W. Kyle					1	4	4*Txl.*	
	Snyder, (Mrs.) M. S.				1				
1941	Snyder, V. D.					1	2	2*Ta.*	
1926	Solcher, Esther Arsinoe					1	1	1*Txl.*	
1933-1942	Soxman, G. M.					3	153	8*Ta*, 142*Sa*, 3*Dnh.*	
1933-1941	Soxman, (Mrs.) G. M.					3	29	5*Txl*, 9*Sa*, 15*Dnh.*	
1932	Spann, Carl					1	4	4*Txl.*	
1934	Spencer, Morman S.					1	1	1*Ta.*	
1939	Spencer, R.				2	1	4	4*Ts.*	
1936-1943	Sperry, Omer E.				55	2	283	115*TR*, 168*Sp.*	
1933	Spinks, Warren					1	1	1*Txl.*	
1941	Spofford, G. E.					1	14	14*Ta.*	
	Stafford, I.					1	1	1*Txl.*	
1919	Stahlmach, A. A.					2	2	1*Txl*, 1*Bg.*	
1915	Standley, Paul C.		1	1					1U.
1894-1899	Stanfield, Silas Walter	2	2	4	21				1Ph, *3Y.
1927-1931	Stanfield, (Mrs.) Virginia E.				3	1	16	16*Txl.*	

TABLE 2 (Continued)

Texas collections†	Texas plant collectors	1 TCh	2 DI	3 TM	4 TFI	5 CI	6 THe	7—44	45—93
----------	Stanford, K.	----	----	----	1	----	----		
1922-1923	Staugaard, Martinius H.	----	----	----	2	2	32	2*SRW*, 30*Th.*	
1911	Stearns, Elmer	3	1	3	2	----	----	----------	*3U.
1931-1935	Steiger, T. L.	----	----	----	22	0	0	0*TR.*	
1938	Stenzel, R. H.	----	----	----	----	1	1	1*Txl.*	
1929	Stephanson, (Mrs. J. H.) Mary R.	----	----	----	6	1	2	2*SM.*	
1931	Stephens, Marie	----	----	----	----	1	1	1*Txl.*	
----------	Stephenson, J.	----	----	----	1	----	----		
----------	Stevens, J. H.	----	----	----	----	1	1	1*HB.*	
----------	Stewart, S.	----	----	----	1	----	----		
1931	Steyermark, Julian Alfred	1	8	12	12	----	----	----------	1Cl, 1Cs, *Dd, 2Gh, *4M, 1Mc, 1Mn, 1Y.
1923.	Stiles, E. P.	----	----	----	----	2	6	5*Txl*, 1*Ts.*	
----------	Stiner, G.	----	1	1	----	----	----	----------	1Tx.
1929	Stockman, Jack	----	1	1	----	----	----	----------	1Tx.
1930	Stoermer, Irene	----	----	----	----	1	2	2*Txl.*	
1931	Stosh, Doris	----	----	----	----	1	2	2*Txl.*	
1938-1941	Strandtmann, R. W.	----	----	----	2	2	30	21*Txl*, 9*Ta.*	
----------	Street, Mary Frances	----	----	----	----	1	2	2*Txl.*	
1932	Stuart, Alpha Mell	----	----	----	----	1	1	1*HB.*	
1933	Stuart, Bobbie	----	----	----	----	1	2	2*Txl.*	
1910-1937	Studhalter, Richart Arthur	3	2	4	8	3	190	31*Txl*, 130*Tt*, 29*TR*	1M, *3U.
1921	Studhalter, Ruth B.	----	----	----	----	1	2	2*Tt.*	
1934	Stungeon, Mary Nell	----	----	----	----	1	1	1*Txl.*	
1934-1939	Sullivan, Florence	----	----	----	----	2	5	3*Txl*, 2*TPv.*	
1928	Sundell, (Miss)	----	----	----	----	1	1	1*Txl.*	
----------	Sutherland, Ernest	----	----	----	----	2	6	5*Txl*, 1*Bg.*	
1933	Suttlehan, T.	----	----	----	----	2	3	2*Txl*, 1*TM.*	
----------	Sutton, V.	----	----	----	1	1	1	1*Txl.*	
1931	Sweet, Ben L.	----	----	----	2	1	1	1*Txl.*	
1853-1856	*Swift, (Dr.) Ebenezer	3	1	2	1	----	----	----------	2Ph.
1930	Swindon, (Mrs.) R. K.	----	----	----	----	1	2	2*Ts.*	
1937	Tabb, Stewart	----	----	----	----	1	8	8*BU.*	
1939	Taber, F. W.	----	----	----	----	1	1	1*Txl.*	
1926	Talley, Paul J.	----	----	----	----	1	14	14*BU.*	
1940	Tansy, Frank	----	----	----	----	1	1	1*Tet.*	
1925-1931	Taubenhaus, J. J.	----	1	1	1	2	5	3*Ta*, 2*Txal.*	
1944	Taylor, Hal	----	----	----	----	1	1	1*HB.*	
1933	Taylor, Mae	----	----	----	----	1	4	4*Txl.*	
1939	Taylor, M. M.	----	----	----	1	2	7	2*Ts*, 5*McC.*	
1940	Taylor, Willie B.	----	----	----	----	1	3	3*Txl.*	
----------	Taylor, W. P.	----	----	----	1	1	65	65*Ta.*	
1930-1933	Teas, Edward	----	----	----	4	2	6	5*Txl*, 1*HM.*	
1908	Tedman,	----	----	----	1	----	----		
1894-1895	Tell, William	27	----	----	----	----	----		
1930	Tejada, Johnie	----	----	----	----	1	1	1*Txl.*	
1938	Templin, E. H.	----	----	----	----	1	5	5*Ta.*	
1932	Terry, Ura	----	----	----	----	1	1	1*Ts.*	
1927	Thames, Lillian	----	----	----	----	1	2	2*Txl.*	
1914-1943	Tharp, Benjamin Caroll	50	7	109	334	18	4174	3760*Txl*, 4*Ts*, 135*SM*, 68*WM*, 46*Tt*, 21*Bg*, 6*TPh*, 4*Ho*, 1*Sa*, 3*JT*, 8*Tet*, 6*HB*, 3*TcW*, 48*TPv*, 24*Sw*, 16*TM*, 20*Tll*, 1*Dnh.*	2Cb, 2M, 33Ph, *46Tx, 21U, 4Y, 1Pe.
----------	Tharp, E. W.	----	----	----	1	----	----		

TABLE 2 (Continued)

Texas collections†	Texas plant collectors	1 TCh	2 DI	3 TM	4 TFI	5 CI	6 THc	7—44	45—93
----------	Tharp, Ruth	----	----	----	1	----	----	----------	----------
1915	Thomas, G. H.	----	----	----	2	1	1	1*Txl.*	
1921	Thomas, Roberta	----	----	----	----	2	2	1*Txl*, 1*WM.*	
1934	Thornton, Mildred	----	----	----	----	1	5	5*Txl.*	
1850-1853	*Thurber, (Dr.) George	145	3	4	13	----	----	----------	1Dd, *2Gh, 1Y.
1880-1927	Thurow, Frederick William	218	----	----	16	3	541	7*Txl*, 68*RW*, 528*Th.*	
1939-1941	Timmons, Durward E.	----	----	----	1	4	122	4*Txl*, 17*Ta*, 71*Ts*, 30*McC.*	
1939	Tindel, M.	----	----	----	1	2	6	3*Ts*, 3*McC.*	
1941	Tischer, Eloise	----	----	----	----	1	3	3*Ho.*	
1938	Todd, (Mrs.) A. P.	----	----	----	----	1	1	1*Txl.*	
1944	Tolstead, W. L.	----	----	----	3	----	----	----------	
1940	Tomes, Mark	----	----	----	----	1	1	1*Ta.*	
1930	Toscano, Tony	----	----	----	----	1	1	1*Txl.*	
1891-1893	Townsend, Charles Henry Tyler.	32	1	1	2	----	----	----------	1U.
1931	Townsend, (Mrs.) M.	----	----	----	----	1	2	2*Txl.*	
1901-1937	Tracy, Samuel Mills	911	13	80	47	3	422	181*Txl*, 240*Ta*, 18*M.*	3B, 1Cl, 1Cm, 9Fm, 10Gh, *9M, 3Mn, 3Nd, 3Ph, 3Tx, *15U, *19Y, 1Pe.
1935	Traylor, W.	----	----	----	1	----	----	----------	
1848-1850	*Trecul, (Dr.) Auguste Adolphe Lucien.	6	1	1	----	----	----	----------	1P.
1900	Trelease, William	----	1	2	13	----	----	----------	2M.
1937	Trent, E.	----	----	----	----	1	7	7*BU.*	
1930	Trevinio, Henry	----	----	----	----	1	1	1*Txl.*	
1889	Trimble, (Miss) S. A.	2	----	----	----	----	----	----------	
1939	Tunnell, C. A.	----	----	----	----	2	7	2*Ts*, 5*McC.*	
1939-1940	Turner, Bert Jane	----	----	----	----	1	14	14*Txl.*	
1939	Turner, M. J.	----	----	----	----	1	1	1*Txl.*	
----------	Turner, P.	----	1	1	----	----	----	----------	1Mn.
----------	Turner, S. T.	----	----	----	1	----	----	----------	
1934	Turneys, Paul	----	----	----	----	1	1	1*Ta.*	
1928	Turpin, S.	----	----	----	----	1	11	11*TPh.*	
----------	Turrell, C. A.	----	----	----	1	----	----	----------	
1879-1880	Tweedy, Frank	1	3	4	9	----	----	----------	*2U, *2Y, *Yl.
1904	Tyler, A. A.	----	----	----	3	----	----	----------	
1904	Tyler, Frederick Jared	1	2	1	2	----	----	----------	*O, 1U.
1931	Upton, R. G.	----	----	----	----	1	3	3*ATc.*	
1939	Uzzell, P. B.	----	----	----	1	----	----	----------	
----------	Vanderwort, Mary	----	----	----	----	1	1	1*Txl.*	
1936-1937	VanGorder, Charles	----	----	----	----	3	15	2*Txl*, 1*Ta*, 12*Sc.*	
----------	VanHuff	----	----	----	1	----	----	----------	
1935	VanMeter, C. E.	----	----	----	1	2	21	15*Ts*, 6*McC.*	
1935	VanMinden, Florence	----	----	----	----	1	1	1*Txl.*	
----------	Vasey, F.	----	----	----	2	----	----	----------	
1881-1888	Vasey, George R.	114	2	2	4	1	1	1*Ta*	1FM, 1M.
1928	Vaughan, Ruby	----	----	----	----	1	1	1*Txl.*	
1898	Vaughan, T. W.	----	----	----	----	1	1	1*Txl.*	
1941	Vaughn, Bernice	----	----	----	----	1	16	16*Ho.*	
1934	Veit, Irene	----	----	----	----	1	2	2*Txl.*	
1937	Vermillion, (Mrs. L.) Marjorie.	----	----	----	----	1	3	3*BU.*	
1902	Vierick,	----	1	1	----	----	----	----------	1Ph.
1934	Viet, Wilma	----	----	----	----	1	3	3*Txl.*	
----------	Vinall,	----	----	----	----	1	1	1*Txl.*	
----------	Vincent,	----	1	1	----	----	----	----------	1P.

TABLE 2 (Continued)

Texas collections†	Texas plant collectors	1 TCh	2 DI	3 TM	4 TFI	5 CI	6 THe	7—44	45—93
1922-1939	Vines, Robert A.	14			3	4	96	2*Ta*, 44*HM*, 26*Ho*, 24*RV*.	
1940-1941	Vines, Ruby V.					2	47	22*Ho*, 25*RV*.	
	Vinzent,	2	2	2	1				1Bm, 1M.
1925-1928	Violette, Horner				1	1	3	3*WM*.	
1937	Voigt, Mary					1	4	4*Txl*.	
1855	Vollom, (Dr.)	10	1	1					1Ph.
1931-1936	von Shrenk, Hermann		1	2	3				2M.
1912	von Struve, H. C.					1	1	1*WM*.	
	Wadsworth, C.				1				
1927-1931	Wadsworth, Ellen					1	25	25*Txl*.	
1892	Wagner, Frank	1							
1943	Wagner, R.				2				
1932	Wainninger, Charles					1	2	2*Txl*.	
1939	Walden, M.					2	6	3*Ts*, 3*McC*.	
1943	Waldorf, Gray					1	1	1*Txl*.	
1939	Walker, Alyce					1	1	1*McC*.	
1939	Walker, Calvin				1	2	12	5*Ts*, 7*McC*.	
1936-1942	Walker, (Mrs. E. J.) Thelma.					2	31	30*Txl*, 1*Ta*.	
1930	Walker, Louise				1	1	7	7*Txl*.	
1936	Walker, T. V.					1	1	1*Ta*.	
1938	Wallace, F.					2	2	2*ATc*.	
1930	Walter, Louise					1	1	1*Txl*.	
1876-1877	Ward, Lester Frank	7	1		8				*U.
1930	Ward, Wilma					1	1	1*Ahs*.	
1931	Warley, Leona				2	1	21	21*WM*.	
1916-1944	Warner, Seldon Richard		1	4	29	3	675	20*Txl*, 3*Ta*, 652*SRW*.	*4M.
1937-1941	Warnock, Barton H.	14			28	4	195	155*Txl*, 31*TR*, 1*TPh*, 8*Sp*.	
1930	Warren, Fred A.					1	16	16*Bg*.	
	Warren, W. H.		1	1					1M.
1943	Waterfall, U. T.					1	36	36*SM*.	
1928-1930	Watkins, Gustav McKee					1	28	28*Txl*.	
1928	Watkins, G. W.					1	1	1*TPc*.	
1928-1931	Watkins, J. M.					1	10	10*Txl*.	
	Watkins, Stella					1	3	3*Txl*.	
1934	Watts, Elizabeth					1	1	1*Txl*.	
	Watts, M. E.				1				
1932	Wear, Lucile					1	3	3*Ts*.	
1944	Weathersby, W. E.					1	1	1*JT*.	
1941-1942	Weaver, J. Nevin				9	2	28	13*SM*, 15*Sw*.	
1936	Weaver, T. V.					3	10	1*Txl*, 3*Ta*, 6*Sc*.	
1939	Webb, N. Martha					1	16	16*BU*.	
	Weed, Alfred C.	1							
1919	Weilbacher, Lena					1	2	2*WM*.	
	Weiniger, John					1	2	2*Txl*.	
	Welch, A. D.				1				
1938	Welch, H.					1	2	2*McC*.	
1914	Werkenthin, Fred				4	1	1	1*Txl*.	
1934	Werlla, Billie Cole					2	5	4*Txl*, 1*TPc*.	
1911	Wesley, Ophelia Clementine.					2	8	7*Txl*, 1*Ts*.	
1930	Westley, J.				3	1	1	1*Txl*.	
1930	Westley, K.					1	1	1*Ahs*.	
	Westley, (Mrs.) R.				1				
1939	Westmorland, Edith					1	4	4*ATc*.	

TABLE 2 (Continued)

Texas collections†	Texas plant collectors	1 TCh	2 DI	3 TM	4 TFI	5 CI	6 THe	7—44	45—93
1939	Wheeler, M.					1	12	12*BU.*	
1901	Wheeler, W. M.					1	9	9*Txl.*	
1939	Whelan, Clare					1	1	1*oL.*	
	Wherry, Edgar Theodore		2	12					*2**Ph,** 4**Y.**
1907	Whitaker, Esther L.	1							
1932	White, Bessie J.					1	8	8*Txl.*	
1936	White, Charles					1	1	1*Sc.*	
1930	White, Ferol					1	1	1*Ahs.*	
1912	White, J. L.				4	1	8	8*Txl.*	
1911-1913	White, Mary J.				3	1	38	38*Txl.*	
1929-1940	Whitehouse, Eula	185	2	13	29	10	689	663*Txl*, 15*Ts*, 1*Bg*, 1*HB*, 1*TcW*, 1*Tct*, 3*TPc*, 1*Sw*, 2*TM*, 1*Tll.*	2**Fm,** *11**Tx.**
1943	Whitfield, Charles J.					1	1	1*Sc.*	
1937	Whitley, Douglass				1	2	21	13*Ts*, 8*McC.*	
1935	Wiegand, K. M.				1				
1935	Wiegand, M. C.				1				
1930-1931	Wiggins, Zada		1	3		1	27	27*Txl.*	3**Tx.**
1932	Wilcox, G.					1	1	1*oL.*	
	Wilczek, E.				1				
1900	Wild, E.					1	2	2*Txl.*	
1893	Wilkes, W. O.	23							
1932	Wilkins, Hans		1	4					*4**Ph.**
	Wilkinson, E.				6				
1926	Wilkinson, J. C.	1				1	2	2*WM.*	
1939	Williams, B.					2	12	11*Ts*, 1*McC.*	
1941	Williams, Carolyn		1		1	1	1	1*HB*	*Ph.
1927	Williams, Charles Barnes	49	2	12	3	1	50	50*Txl*	9**Ph,** 3**Tx.**
	Williams, D. B.								1**Ph.**
1937	Williams, H. L.					1	1	1*Ta.*	
1933	Williams, Lloyd		1	1		1	7	7*Txl*	1**Tx.**
1942	Williams, Louise				1	1	1	1*ATc.*	
1941	Williams, Mary Elizabeth					1	6	6*BU.*	
1900	Williams, Thomas Albert	1							
1938-1940	Williams, U. H.					1	18	18*Ta.*	
1930	Williams, V.					1	1	1*Txl.*	
	Williamson, C. B.				2				
	Williamson, C. H.				1				
	Williamson, Charles Sumner.		1						*Ph.
1938	Williamson, Glenn					2	6	5*Ts*, 1*McC.*	
1934	Willis, R.					1	1	1*Txl.*	
1929	Wilson, Eugene A.					1	2	2*WM.*	
1935	Wilson, J.					1	3	3*Tr.*	
1941	Wilson, Percy					1	6	6*ATc.*	
	Wimberley, W. W.				1				
	Wimberley, (Mrs.) W. W.				1				
1932	Winans, L. L.				1	1	4	4*Txl.*	
1901-1910	Winckler, Charles Herman				4	1	11	11*Txl.*	
1934-1941	Winkler, P. A.		1	1		4	5	1*Txl*, 2*Ta*, 1*HM*, 1*Ho.*	
1932	Winnedge, Mable					1	1	1*Txl.*	
1935	Winston, M. R.					1	1	1*Txl.*	
1930	Wiseman, (Mrs.) Gertrude B.					1	2	2*Txl.*	
1846	*Wislizenus, (Frederick) Adolphus.	2			1				

TABLE 2 (Continued)

Texas collections†	Texas plant collectors	1 TCh	2 DI	3 TM	4 TFI	5 CI	6 THe	7—44	45—93
1929	Witherspoon, Mary					1	2	2*Txl.*	
1939-1942	Wolcott, Gordon B.					1	16	16*Sw.*	
1941	Wolf, Mary Helen					1	7	7*BU.*	
1908-1910	Wolf, Frederick Adolph				1	2	18	17*Txl.* 1*Bg.*	
1888	Wolf, (Dr.)	1							
1928-1934	Wolff, Simon Emanuel		2	23	65	3	1007	2*Txl,* 423*Ta,* 582*Txal.*	15**Txa,** 8**U.**
1929-1931	Wood, (Mrs.) Myrtle B.		1	1		1	26	26*Txl*	1**Tx.**
1931	Woodall, Ben Davis					1	1	1*Txl.*	
1850	*Woodhouse, (Dr.) Samuel Washington.	1							
1931	Woodruff, Kathlene					1	1	1*Txl.*	
1929	Woods, (Miss) B. L.					1	1	1*Txl.*	
1929	Woodson, R. E.					1	1	1*Txl.*	
1939	Woolfolk, Jo.					2	16	6*Ts,* 10*McC.*	
1931	Woolridge, R.					1	1	1*Txl.*	
1874	Woolson, George Clark	1							
1941-1942	Wooten, H. G.					1	4	4*TPh.*	
1903-1925	Wooton, E. O.		8	10	5				1**Ar,** 1**Cl,** 1**Dd,** 1**Gh,** 1**M,** 1**Po,** 3**U,** 1**Y.**
1931	Worley, Leona	3							
	Worthington, Clarence					1	2	2*Txl.*	
1931	Wren, (Mrs.) J. L.					1	1	1*Txl.*	
	Wright, A. A.				1				
	Wright, A. H.				1				
	Wright, A. S.				1				
1837-1863	**Wright, Charles	61	7	35	56				3**Cl,** *13**Gh,** 1**K,** 5**M,** 1**Ph,** 9**U,** 3**Y.**
1934	Wright, Harold					1	4	4*Txl.*	
1890-1891	Wurzlow, Hugo	75	1	1	10	1	1	1*Th*	1**Ill.**
1930	Ximenis, Minnie*					1	2	2*Txl.*	
1937-1939	Yarbrough, John A.					1	37	37*BU.*	
1937	Yarbrough, (Mrs.) John A.					1	1	1*BU.*	
1937-1942	York, (Capt.) Christopher LaFayette.				1	1	119	119*Txl.*	
1907-1909	York, Harlan Harvey		3	4	12	4	142	138*Txl,* 2*Ts,* 1*TPc,* 1*TM.*	2**Dd,** *2**Gh,** *2**Tx.**
	Young, Frances					1	1	1*Txl.*	
	Young, H. W.				1				
1913-1918	Young, Mary Sophie	1	5	20	84	3	663	675*Txl,* 3*Ts,* 3*TPc*	2**Gh,** 5**M,** 1**Ph,** *10**Tx,** 2**U.**
	Young, P. A.				1				
1932	Young, Virginia					1	5	5*Txl.*	
1936	Young, (Mrs.)					1	1	1*HB.*	

* One sheet spelled "Himenis".

Distribution of Aquatic Mollusks in Minnesota*

Charlotte Dawley

Introduction

Although Minnesota is a state abounding in lakes and rivers of all sizes which contain a varied molluscan fauna, no general survey of its fresh-water mollusks has as yet been published. Such a survey is of interest from a geographical point of view because the waters of Minnesota drain in three directions, namely south through the Mississippi River to the Gulf of Mexico, east through Lake Superior to the St. Lawrence River, and north through the Red and Rainy Rivers to Hudson Bay. Moreover the rivers as well as the lakes, of which there are more than 10,000, present a wide range of size and of chemical and physical characteristics which make the distribution of mollusks interesting from an ecological standpoint.

The earliest published records of Minnesota mollusks are those of Thomas Say (1825) and William Cooper (1834) which are little more than lists of the species found on some of the early exploring expeditions sent into this territory. In 1885 U. S. Grant, a member of the staff of the Minnesota Geological and Natural History Survey, published a list of the mollusks of the Mississippi, Minnesota, and Red River systems, and in 1887 he reported on the mollusks of St. Louis County in the northern part of the state. In 1887 also John M. Holzinger published a paper on the mollusks of Winona County in the southern part of the state. Sargeant (1895, 1896), Stearns (1900), and Daniels (1909) listed the species found in some of the lakes and rivers in various parts of Minnesota and described their habitats and relative abundance. The mussels in the rivers of central and southern Minnesota were studied by Wilson and Danglade (1914) and Grier and Mueller (1922, 1926) in connection with investigations of the pearl button industry made by the U. S. Bureau of Fisheries. F. C. Baker (1929, 1935) published two studies on the mollusks of individual lakes in the northern part of the state.

The collection of shells in the Zoology Department of the University of Minnesota forms the basis for this study.** This collection was started seventy years ago by members of the staff of the Minnesota Geological and Natural History Survey and has since been augmented by persons in the Zoology Department and others. Its present organization and scope are largely due to Dr. Samuel Eddy of the Zoology Department. In 1931 a survey of Minnesota lakes was begun under his supervision, and many mollusks were brought in by field workers. The writer became interested in Minnesota mollusks in

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** The two groups of mollusks included in this paper are mussels and aquatic snails. The Sphaeriidae are omitted because of the uncertain condition of the taxonomy in this family.

the summer of 1936, and in order to make the survey more complete, made several collecting trips during the summers of 1938, 1939, and 1940 to parts of the state not previously studied. The data now include collections from 150 lakes in 44 of the 86 counties of the state, from 70 stations on 30 rivers and streams, and from 50 ponds in three different regions of the state.

In any study of animal distribution two ultimate questions to be considered are why certain species are found in some habitats but not in others, and what determines the geographical limits within which a species is found. Exact information concerning the geographical and ecological distribution of any species is necessary before such questions can be answered.

The environment of a mollusk must provide it with food, oxygen, and calcium for a shell. In addition it must furnish the proper conditions for reproduction. A mussel is more exacting in its requirements than a snail, being heavier and less motile. The bottom in which it lives may be sand, gravel, or mud, but not rock or soft muck because its foot cannot penetrate rock and it sinks too far into the muck and is smothered. It lives best where a current of water brings suspended food material, oxygen, and some form of calcium within reach of the cilia lining its mantle cavity. For this reason more species of mussels are found in rivers than in lakes. Snails, being smaller and lighter and more motile, are able to live almost anywhere where there is water and vegetation and therefore are the principal mollusks in lakes and ponds. Whereas mussel shells are almost pure calcium carbonate, snail shells in addition, contain chitin which probably accounts for the presence of snails in some waters containing very little calcium. Experience has shown that the calcium carbonate content of Minnesota waters can usually be measured as the total alkalinity (T.A.). The waters in this state vary in total alkalinity from less than twenty parts per million in some of the lakes on the Canadian border to more than 300 parts per million in the western part of the state. Where not otherwise noted, the total alkalinities quoted are taken from Dole and Wesbrook (1907).

The range of an animal may be limited by such environmental factors as food, temperature, or moisture, or by a physical barrier of some kind. In the case of freshwater animals land is a barrier and their range is limited by the discontinuous character of lakes, ponds, and even rivers—the rivers of one drainage system being separated from those of another. Unless an aquatic species can live temporarily on land or has some means of being transported over land, its distribution may be limited to one drainage system. Snails and fingernail clams, being small and light, can be transported by water birds in the mud which clings to their feet, and therefore are seldom restricted to any one drainage system, but mussels are too large and heavy to be carried by birds. Also the glochidial stage parasitic on fish makes the distribution of most mussels dependent on that of their fish host. The range of many mussels has undoubtedly been increased by migrating fish and it is even conceivable that in recent times man, by transplanting fish, might have accidentally transplanted mussels also. This, however, seems to be exceedingly rare. In general the range of a species of mussel is restricted to a single drainage system, and the presence of the same species in two or more separate drainage systems has been

considered evidence that the two systems were connected at one time (van der Schalie, 1939).

Distribution is of two types, geographical and ecological. In this study geographical distribution means distribution according to drainage system and is largely concerned with the effects of physical barriers on the migration of mussels. Snails seem to be able to surmount such barriers and their distribution does not show much relation to drainage systems in Minnesota. Ecological distribution is concerned with the effect on the distribution of both mussels and snails of the various sets of environmental conditions that are found within the boundaries of any one drainage system.

Geographical Distribution

At the present time the three drainage systems in Minnesota, namely the Mississippi, the Hudson Bay, and the St. Lawrence, are separate, but geological evidence shows that during the retreat of the last glacier, while the ice still blocked the north, all of the rivers in the state drained southward into the Mississippi River. Since most of the mussels in Minnesota are also found in the states farther south, it seems probable that most of them emigrated northward through the Mississippi River and its tributaries. Inasmuch as the post-glacial connections between these three major drainages were only temporary, the mussels which are today found in all three drainages must be the species which have the most efficient means of migration or the greatest powers of survival.

MISSISSIPPI DRAINAGE

The Mississippi River, which drains more than half of the state, rises in Lake Itasca in the north central part. It starts off northward, swings around eastward in a wide arc through Lake Bemidji, Cass Lake, and Lake Winnibigoshish to Grand Rapids, then southeast to Jacobson, southwest to Brainerd, south to Little Falls, and southeast again to Minneapolis where it passes over the St. Anthony Falls. A few miles below Minneapolis two important tributaries enter. One is the Minnesota River, a broad, shallow river which rises on the North Dakota border, flows across the western part of the state and enters the Mississippi just below Minneapolis at Fort Snelling. The other is the St. Croix River which rises in northern Wisconsin and after forming the boundary between that state and Minnesota for most of its course, enters the Mississippi at Hastings, thirty miles below Minneapolis. In the area around the town of Taylors Falls, the banks are steep and rocky and the river is turbulent and full of rapids, the largest being St. Croix Falls. Elsewhere there are quiet stretches and just before the St. Croix enters the Mississippi River at Hastings, it widens into a river-lake, Lake St. Croix. South of Hastings the Mississippi River, which forms the boundary between Minnesota and Wisconsin, is the largest river in the state. In this portion of the river is Lake Pepin, a large lake-like expansion between Red Wing and Reeds Landing.

Forty-four of the forty-five species of mussels found in Minnesota were found in the rivers or lakes of the Mississippi drainage. The one exception,

Elliptio complanatus, is common in the eastern part of the United States in the Atlantic drainage, but was found in Minnesota only in Lake Superior. Two species, *Anodonta marginata* and *Anodonta kennicotti,* although present within the Mississippi drainage area, were found only in lakes. The part of the Mississippi River below St. Anthony Falls contained thirty-nine species, which is the largest number of species found in a single river anywhere in the state. This is to be expected because the Mississippi is the largest river in the state and contains a variety of favorable habitats. Also the lower part of the river was not covered by the last glacier and was the channel through which the other rivers in the state were repopulated. The first four columns in Table 1 list the mussels found in the Mississippi River both above and below St. Anthony Falls and in its two principal tributaries, the St. Croix and Minnesota Rivers. The most striking thing about this comparison is the small number of species found in the Mississippi River above St. Anthony Falls as compared with the number in either the St. Croix or the Minnesota Rivers.

Table 1.—Distribution of mussels according to drainages.

	Mississippi R. below Minneapolis	Mississippi R. above Minneapolis	St. Croix R.	Minnesota R.	St. Lawrence	Hudson Bay
1. *Fusconaia undata*	x		x	x		
2. *Fusconaia ebenus*	x					
3. *Fusconia flava*			x			
4. *Megalonaias gigantea*	x		x	x		
5. *Amblema peruviana*	x		x	x		
6. *Amblema rariplicata*	x		x	x		
7. *Amblema costata*	x		x			x
8. *Quadrula quadrula*	x			x		x
9. *Quadrula pustulosa*	x		x	x		
10. *Quadrula metanevra*	x					
11. *Tritogonia verrucosa*	x		x	x		
12. *Cyclonaias tuberculata*	x		x			
13. *Plethobasus cyphyus*	x		x	x		
14. *Pleurobema cordatum coccineum*	x		x	x		
15. *Elliptio dilatatus*	x		x	x		
16. *Elliptio complanatus*					x	
17. *Elliptio crassidens*	x			x		
18. *Lasmigona compressa*		x	x		x	x
19. *Lasmigona costata*	x		x	x		x
20. *Lasmigona complanata*	x		x	x	x	x
21. *Anodonta grandis*	x	x	x	x	x	x
22. *Anodonta marginata*		x			x	x
23. *Anodonta gigantea*	x			x		
24. *Anodonta corpulenta*	x		x	x		
25. *Utterbackia imbecillis*	x	x	x	x		
26. *Anodontoides ferussacianus*		x	x	x	x	x
27. *Alasmidonta marginata truncata*	x		x	x		
28. *Arcidens confragosus*	x			x		
29. *Strophitus rugosus*	x		x			x
30. *Obliquaria reflexa*	x		x	x		x
31. *Obovaria olivaria*	x		x	x		
32. *Actinonaias carinata*	x	x	x	x		x
33. *Truncilla truncata*	x		x	x		
34. *Truncilla donaciformis*	x			x		
35. *Plagiola lineolata*	x			x		
36. *Leptodea fragilis*	x		x	x		
37. *Proptera alata megaptera*	x		x	x		x
38. *Proptera laevissima*	x		x	x		
39. *Carunculina parva*	x		x	x		
40. *Ligumia recta latissima*	x	x	x	x	x	x
41. *Lampsilis fallaciosa*	x			x		
42. *Lampsilis siliquoidea*	x	x	x	x	x	x
43. *Lampsilis ventricosa*	x	x	x	x	x	x
44. *Lampsilis higginsi*	x		x	x		

Table 2.—Distribution of mussels in the Mississippi River.

	Alida	above Cass Lake	Brainerd	Fort Ripley	Little Falls	Clearwater	Elk River	Dayton	Anoka	Fridley	Nininger*	Red Wing*	Lake City**	Minneiska*	Winona*	Dresbach*
1. *Fusconaia undata* ...												x	x	x	x	
2. *Fusconaia ebenus* ...												x	x	x	x	x
3. *Megalonaias gigantea*												x	x		x	
4. *Amblema peruviana*.												x	x		x	x
5. *Amblema rariplicata*.												x				
6. *Quadrula quadrula*..											x	x	x			
7. *Quadrula pustulosa*..											x	x		x	x	x
8. *Quadrula metanevra*.											x	x	x		x	x
9. *Tritogonia verrucosa*											x	x	x	x	x	x
10. *Cyclonaias tuberculata*												x				
11. *Plethobasus cyphyus* .												x		x		x
12. *Pleurobema cordatum coccineum*													x			
13. *Elliptio dilatatus* ...											x	x	x	x	x	
14. *Elliptio crassidens* ..												x	x		x	
15. *Lasmigona compressa*	x	x														
16. *Lasmigona costata* ..												x	x	x	x	
17. *Lasmigona complanata*												x	x	x	x	
18. *Anodonta grandis* ..		x					x	x	x			x	x			
19. *Anodonta gigantea* ..												x	x			
20. *Anodonta corpulenta*												x	x		x	
21. *Utterbackia imbecillis*										x			x			
22. *Anodontoides ferussacianus*	x	x														
23. *Alasmidonta marginata truncata*..												x			x	
24. *Arcidens confragosus*												x		x		
25. *Strophitus rugosus* ..												x	x			
26. *Obliquaria reflexa* ..												x	x	x		x
27. *Obovaria olivaria* ...												x			x	x
28. *Actinonaias carinata*.			x	x						x	x	x		x	x	x
29. *Truncilla truncata* ..											x	x	x		x	
30. *Truncilla donaciformis*												x				
31. *Plagiolata lineolata* .											x	x	x	x		
32. *Leptodea fragilis* ...												x	x			
33. *Proptera alata megaptera*											x	x	x		x	x
34. *Proptera laevissima*..												x	x			
35. *Carunculina parva* ..													x			
36. *Ligumia recta latissima*		x	x	x	x	x	x	x	x	x		x	x	x	x	x
37. *Lampsilis fallaciosa*..												x	x			
38. *Lampsilis siliquoidea*		x	x	x	x	x	x	x	x	x		x	x	x	x	x
39. *Lampsilis ventricosa*.		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
40. *Lampsilis higginsi* ..												x				x

* below Minneapolis
** on Lake Pepin

Table 2 shows the species collected at ten stations above St. Anthony Falls and at six stations in the river south of the Falls, and Table 3 shows the species in the various tributaries both above and below St. Anthony Falls.

Beginning with the headwaters, the first mussel to appear in the river was *Anodontoides ferussacianus*, although *Anodonta marginata* and *Lampsilis siliquoidea* were in Lake Itasca. A few miles farther down *Lasmigona compressa* appeared. The four most common species, *Anodonta grandis, Lampsilis siliquoidea, Lampsilis ventricosa,* and *Ligumia recta latissima,* were first found about forty miles from Lake Itasca where the river was still small, and from there down they were almost always present. Above St. Anthony Falls,

Table 3.—Distribution of mussels in tributaries of the Mississippi River.

	Prairie R.	Crow Wing R.	Swan R.	Platte R.	Sauk R.	St. Francis R.	Elk R.	Crow R.	Rum R.	Coon Creek	Cannon R.*	Straight R.*	Zumbro R.*	Root R.*	Red Cedar R.*
1. *Amblema costata*															x
2. *Lasmigona compressa* ...					x				x	x					
3. *Lasmigona complanata* ..													x	x	x
4. *Anodonta grandis*	x		x	x	x		x	x	x		x	x	x		x
5. *Utterbackia imbecillis* ..									x						
6. *Anodontoides ferussacianus*				x	x		x		x	x					x
7. *Strophitus rugosus*													x		x
8. *Actinonaias carinata* ...		x							x		x	x			
9. *Proptera alata megaptera*											x				
10. *Ligumia recta latissima*..	x	x					x	x	x			x			
11. *Lampsilis siliquoidea* ...	x	x	x		x	x	x	x	x		x	x	x	x	x
12. *Lampsilis ventricosa*	x	x			x		x	x	x			x			

* below Minneapolis

Actinonaias carinata was found in a few places both in the main river and in two tributaries, but was not abundant. *Utterbackia imbecillis* was collected in fairly large numbers at Fridley and in the Rum River near Anoka, both places being about 500 miles below Lake Itasca, and about twenty miles north of St. Anthony Falls.

There seems to be no reason for this scarcity of species on grounds of chemical or physical conditions because the few species that were present were abundant. The total alkalinity in this part of the river ranges from 100 to 200 parts per million. Extensive collecting has been done in the upper Mississippi by survey crews of the University of Minnesota and the Department of Conservation, and although large numbers of mussels have been brought in and examined, the results from a taxonomic standpoint were monotonous—only eight species in the 500 miles of river and ten tributaries between Lake Itasca and St. Anthony Falls. The most likely explanation is that St. Anthony Falls has acted as a barrier to post-glacial migration up the river. In 1885 Grant reported 27 species from Fort Snelling a few miles below St. Anthony

Falls, and although at the present time pollution has eliminated the mussels from this area which is just below St. Paul and Minneapolis, this record is evidence that at least 27 species had migrated this far. Only five species have ever been reported from Fridley about five miles above St. Anthony Falls.

Table 4 shows the thirty-three species of mussels which have been collected from four stations in the St. Croix River and from six tributary streams. The total alkalinity ranges from 50 to 150 parts per million, which is lower than for other parts of the upper Mississippi drainage. The St. Croix Falls, located at the town of Taylors Falls, does not seem to have been much of a barrier to the migration of mussels. Although collecting has not been as extensive as in the upper Mississippi, seventeen species have been found in the

Table 4.—Distribution of mussels in the St. Croix River and its Tributaries.

	Federal Rec. Area in Pine Co.	Taylors Falls	Marine	Lake St. Croix	Kettle R.	Big Sand Creek	Rush Creek	Sunrise R.	Snake R.	Grindstone R.
1. *Fusconaia undata*		x	x	x						
2. *Fusconaia flava*		x				x	x			
3. *Megalonaias gigantea*				x						
4. *Amblema peruviana*				x						
5. *Amblema rariplicata*			x							
6. *Amblema costata*					x			x	x	
7. *Quadrula postulosa*		x	x	x						
8. *Tritogonia verrucosa*		x		x						
9. *Cyclonaias tuberculata*				x				x		
10. *Plethobasus cyphyus*		x								
11. *Pleurobema cordatum cuccineum*		x							x	
12. *Elliptio dilatatus*	x		x							
13. *Lasmigona compressa*							x	x		x
14. *Lasmigona costata*									x	
15. *Lasmigona complanata*				x						
16. *Anodonta grandis*				x			x			
17. *Anodonta corpulenta*			x							
18. *Utterbackia imbecillis*			x							
19. *Anodontoides ferussacianus*							x			
20. *Alasmidonta marginata truncata*								x	x	
21. *Strophitus rugosus*	x	x		x	x	x		x		x
22. *Obliquaria reflexa*		x		x						
23. *Obovaria olivaria*	x	x						x		
24. *Actinonaias carinata*	x		x		x	x		x	x	
25. *Truncilla truncata*		x		x						
26. *Leptodea fragilis*		x		x						
27. *Proptera alata megaptera*				x					x	
28. *Proptera laevissima*			x							
29. *Carunculina parva*			x							
30. *Ligumia recta latissima*	x		x	x	x				x	
31. *Lampsilis siliquoidea*	x			x				x	x	
32. *Lampsilis ventricosa*	x		x					x	x	
33. *Lampsilis higginsi*				x						

Table 5.—Distribution of mussels in the Hudson Bay drainage, Minnesota River, and the St. Lawrence drainage.

	Hudson Bay drainage				Minn. R. drainage						St. Lawrence drainage	
	Red Lake R.	Red R.	Bear R.*	Sturgeon R.*	Minn. R.**	Ft. Snelling	above New Ulm	Blue Earth R.	Cottonwood R.	Chippewa R.	St. Louis R. and tributaries	Lake Superior
1. *Fusconaia undata*						x	x					
2. *Fusconaia flava*	x	x										
3. *Megalonaias gigantea*						x						
4. *Amblema peruviana*						x						
5. *Amblema rariplicata*						x	x					
6. *Amblema costata*	x	x										
7. *Quadrula quadrula*		x				x						
8. *Quadrula postulosa*						x	x					
9. *Tritogonia verrucosa*						x						
10. *Plethobasus cyphyus*							x					
11. *Pleurobema cordatum coccineum*					x							
12. *Elliptio dilatatus*						x		x				
13. *Elliptio crassidens*					x							
14. *Elliptio complanatus*												x
15. *Lasmigona compressa*											x	
16. *Lasmigona costata*	x				x							
17. *Lasmigona complanata*	x			x		x	x					x
18. *Anodonta grandis*	x	x		x		x					x	x
19. *Anodonta gigantea*						x						
20. *Anodonta corpulenta*						x						
21. *Utterbackia imbecillis*						x						
22. *Anodontoides ferussacianus*			x	x			x		x		x	
23. *Alasmidonta marginata truncata*					x							
24. *Arcidens confragosus*						x						
25. *Strophitus rugosus*	x	x										
26. *Obliquaria reflexa*		x				x						
27. *Obovaria olivaria*						x						
28. *Actinonaias carinata*		x		x			x					
29. *Truncilla truncata*						x	x					
30. *Truncilla donaciformis*						x						
31. *Leptodea fragilis*						x	x					
32. *Proptera alata megaptera*	x	x				x						
33. *Proptera laevissima*						x				x		
34. *Carunculina parva*						x						
35. *Ligumia recta latissima*	x	x					x	x				x
36. *Lampsilis fallaciosa*						x						
37. *Lampsilis siliquoidea*	x	x	x	x		x					x	x
38. *Lampsilis ventricosa*	x	x		x	x	x	x					x
39. *Lampsilis higginsi*							x					
40. *Plagiola lineolata*						x						

* Tributaries of the Rainy R.
** No location designated

river and its tributaries above the falls. Geological evidence furnished by the pot holes and old channels around Taylors Falls suggests that in the early post-glacial period before the river cut the gorge, it flowed through a series of cascades and there were no abrupt falls to act as a barrier.

Table 5 shows the thirty-four species of mussels which have been collected from the Minnesota River and its tributaries. The total alkalinity ranges from 150 to 300 parts per million. Very little recent collecting has been done in this river, and very little collecting has ever been done in the upper part or in its smaller tributaries. All species found occurred abundantly in the Mississippi below the mouth of the Minnesota River.

HUDSON BAY DRAINAGE

About one-third of Minnesota, the northern and western portions, drains north into Hudson Bay. The two principal rivers of this drainage are the Rainy River which separates Minnesota from Canada and the Red River which rises close to the Minnesota River on the North Dakota border but flows northward. Fourteen species of mussels have been found in this drainage —thirteen from the Red River and its tributaries and six from the Rainy River drainage. They are listed in Table 5. The small number of species reported from the Rainy River drainage may be due either to its remoteness from the source of post-glacial migration or to the fact that only a few rivers in this drainage have been explored for mollusks. Almost all of the collecting has been done in the Sturgeon River in St. Louis County. Very few chemical analyses have been made of the waters of the Rainy River drainage, but in some places at least the total alkalinity is much lower than in the Red River, which varies from 150 to 200 parts per million.

Eleven of the fourteen species from the Red River drainage were found also in the Minnesota River, the other three, *Fusconaia flava, Amblema costata,* and *Strophitus rugosus,* being small river forms which might be found in the Minnesota drainage if the tributaries were more thoroughly explored. This similarity in species is easily explained by the extensive post-glacial connection between their headwaters. At present, Bigstone Lake on the North Dakota border, the source of the Minnesota River, and Lake Traverse which drains into the Red River are only a few miles apart, and are sometimes connected during periods of extremely high water. After the last glacier, the whole northwestern part of the state, which now drains north through the Red River, was occupied by Lake Agassiz, a huge glacial lake which drained southward through the River Warren in the present valley of the Minnesota River. During this period considerable migration of mussels could have taken place. The discovery of shells of *Amblema costata, Lampsilis siliquoidea, Lampsilis ventricosa, Lasmigona complanata,* and *Ligumia recta latissima* in the debris excavated from the bed of glacial Lake Agassiz is further proof that the conditions were suitable for mussels.

ST. LAWRENCE DRAINAGE

About a tenth of the state, the northeastern part, drains into Lake Superior either through the St. Louis River at the extreme western end or through

many small rivers running directly into the lake on its northern border. Two species, *Anodonta marginata*, and *Elliptio complanatus*, probably entered Minnesota through this drainage. *Elliptio complanatus* is common in the Atlantic drainage but not in the Mississippi and Walker (1913) who first reported this species in Lake Superior, thought that it had migrated in early post-glacial times from the St. Lawrence River through the Trent outlet into Lake Huron and from there into Lake Superior. *Anodonta marginata* is widely distributed in the northern part of the United States and in Canada in both the St. Lawrence and upper Mississippi drainages.

Mussels are not abundant in the St. Lawrence drainage in Minnesota. They are entirely absent from the rushing, turbulent streams which run into Lake Superior on its north shore. The total alkalinity of these streams is low, from 30 to 85 parts per million (Smith and Moyle, 1944). But the total absence of mussels is probably due to the fact that these streams have rocky bottoms and also that just above the mouths of most of them there are falls over which it would be impossible either for adult clams or for glochidia-bearing fish to migrate. The St. Louis River at the western end of the lake is a placid, winding stream flowing through bogs and pine woods and in most places its soft, muddy bottom is not firm enough for mussels. Thin and badly eroded specimens of *Anodonta grandis*, *Anodontoides ferussacianus*, *Lampsilis siliquoidea*, and *Lasmigona compressa* were occasionally found in this river and its tributaries. The total alkalinity is about 60 parts per million.

The north shore of Lake Superior in Minnesota is mainly rock, but even in the few sandy coves there were no mussels. According to Eddy (1943) in a report on limnological studies in Lake Superior "The marginal plant and animal life was practically absent from most of the Minnesota shore due to the heavy wave action". The only part of the south shore which is in Minnesota is Minnesota Point, a narrow spit of sand projecting into the lake at the mouth of the St. Louis River in Duluth. On this point dead shells of *Elliptio camplanatus*, *Anodonta grandis*, *Lampsilis siliquoidea*, *Lampsilis ventricosa*, *Lasmigona complanata*, and *Ligumia recta latissima* have recently been collected. With the exception of *Elliptio complanatus* these are all species which are common in the Mississippi drainage and which might have entered during the retreat of the last glacier when glacial Lake Duluth in the Lake Superior area drained southward through the present St. Croix valley. An outline of the mussels found in this drainage is given in tables 1 and 5.

Ecological Distribution

Within the boundaries of any one drainage system are to be found many different types of environments. In Minnesota the aquatic environments include not only streams of various sizes, but also lakes and ponds. These different environments differ in such characteristics as movement or stillness of the water, chemical composition, depth, kind of bottom, amount of vegetation, etc. Some species of mollusks have a wide range of tolerance of such conditions and are found in a variety of habitats, while others are limited to one or two.

Fresh water environments fall easily into two groups—1) moving waters, such as rivers and streams, and 2) standing waters such as lakes and

ponds. This classification is not rigid for the parts of rivers along the edges and behind barriers become pond-like and many lakes with an inlet and outlet have a considerable flow of water at these points. Moving waters have been divided into four categories. The division is made primarily on the basis of size, but size is correlated in most instances with differences in depth, current, and bottom.

Habitat 1. SMALL STREAMS

Small streams are usually less than ten feet wide and shallow enough to be waded. Inlets and outlets of lakes, headwaters of rivers, and streams flowing through the bottoms of ravines belong to this category. Streams which have been studied in Minnesota are: Nicollet and Chambers Creeks flowing into Lake Itasca and the Mississippi River flowing out, Rice and Coon Creeks north of Minneapolis, and the outlet of Tanners Lake in Washington County. The chemical composition of these streams varies with the local conditions of the region in which they are found, but the physical characteristics are fairly constant. The current is swift, the water shallow, and the bottom made of stones or gravel. In the pool-like stretches vegetation is abundant. Mussels were rare, but fingernail clams and snails were abundant, although only a few species were found at any one place. Below is a composite list of the species found.

Mussels

Anodontoides ferussacianus
Lampsilis siliquoidea
Lasmigona compressa

Snails

Amnicola limosa
Ferrissia tarda
Gyraulus deflectus obliquus
Gyraulus parvus
Helisoma antrosa
Helisoma campanulata
Helisoma trivolvis
Lymnaea caperata
Lymnaea modicella
Lymnaea palustris
Lymnaea stagnalis appressa
Physa gyrina
Physa integra
Physa michiganensis
Planorbula armigera
Valvata tricarinata

Probably the two species most characteristic of small streams in Minnesota are the mussel, *Anodontoides ferussacianus*, and the snail, *Physa integra*. *Physa michiganensis*, which is purely a small creek form (Clench, 1926), has been found only once in Minnesota. Most of the species found in small streams were forms which could live in many different environments or they were lake forms which have spread to the connecting streams.

Habitat 2. SMALL RIVERS

These rivers range in width from ten to fifty feet. In places there are deep, quiet pools, but elsewhere the bottom is stony, the water shallow, and the current swift. Vegetation is confined to areas near the shore. In Minnesota the Mississippi River from Alida to Cass Lake, the Prairie River, the Zumbro River at Kenyon, and the Sturgeon River in St. Louis County are examples of small rivers which have been studied. In these rivers mussels are abundant, the following being a composite list:

Alasmidonta marginata truncata
Amblema costata
Anodonta grandis
Anodontoides ferussacianus
Fusconaia flava
Ligumia recta latissima
Lampsilis ventricosa
Lasmigona complanata
Lasmigona compressa
Lampsilis siliquoidea
Strophitus rugosus

The following snails were found in small rivers:

Amnicola limosa
Campeloma decisum
Ferrissia parallela
Ferrissia tarda
Helisoma antrosa
Helisoma campanulata
Helisoma trivolvis
Lymnaea megasoma
Lymnaea modicella
Lymnaea palustris
Lymnaea stagnalis appressa
Physa gyrina
Physa integra

Habitat 3. MEDIUM-SIZED RIVERS

These rivers are from fifty to one hundred feet wide and quite deep in the center. They offer at least two types of environment, deep pools where the current is slow and the bottom sand or mud, and shallow rapids where the bottom is stony and the current swift. Examples of medium-sized rivers in Minnesota are the Rum River where it enters the Mississippi, the St. Croix River above Taylors Falls, the Red Lake River, and the Mississippi River from Jacobson to Little Falls. The following mussels were found:

Actinonaias carinata
Amblema costata
Amblema rariplicata
Anodonta grandis
Elliptio dilatatus
Fusconaia flava
Lampsilis siliquoidea
Lampsilis ventricosa
Lasmigona complanata
Lasmigona costata
Ligumia recta latissima
Pleurobema cordatum coccineum
Proptera alata megaptera
Quadrula pustulosa
Strophitus rugosus
Utterbackia imbecillis

The following snails were found in medium-sized rivers:

Amnicola integer
Amnicola limosa
Campeloma decisum
Helisoma antrosa
Helisoma trivolvis
Lymnaea catascopium
Lymnaea megasoma
Lymnaea stagnalis appressa
Physa gyrina
Physa integra
Pleurocera acuta tracta
Somatogyrus subglobosus

Habitat 4. LARGE RIVERS

This category includes the largest rivers in Minnesota, namely the Mississippi River below Little Falls, and the lower parts of the Minnesota and St. Croix Rivers. They are broad and deep and for the most part are bordered by sandy beaches or broad flood plains often filled with sloughs and marshes. River-lakes such as Lake Pepin and Lake St. Croix which are simply widenings of the river are included. In general, the larger the river the greater the number of species of mollusks, especially mussels. The following were found in large rivers in Minnesota:

Actinonaias carinata
Alasmidonta marginata truncata
Amblema peruviana
Anodonta corpulenta
Anodonta grandis
Anodonta gigantea
Arcidens confragosus
Carunculina parva
Cyclonaias tuberculata
Elliptio dilatatus
Elliptio crassidens
Fusconaia ebenus
Fusconaia undata
Lampsilis fallaciosa
Lampsilis higginsi
Lampsilis siliquoidea
Lampsilis ventricosa
Lasmigona complanata
Lasmigona costata
Leptodea fragilis
Ligumia recta latissima
Megalonaias gigantea
Obliquaria reflexa
Obovaria olivaria
Plagiola lineolata
Plethobasus cyphyus
Pleurobema cordatum coccineum
Proptera alata meg:ptera
Proptera laevissima
Quadrula metanevra
Quadrula pustulosa
Quadrula quadrula
Strophitus rugosus
Tritogonia verrucosa
Truncilla donaciformis
Truncilla truncata
Utterbackia imbecillis

The following snails were collected from large rivers:

Amnicola emarginata
Amnicola integer
Campeloma decisum
Ferrissia tarda
Helisoma trivolvis
Lioplax subcarinata
Lymnaea modicella
Lymnaea stagnalis appressa
Planorbula armigera
Pleurocera acuta tracta
Somatogyrus subglobosus
Somatogyrus tryoni
Valvata tricarinata
Viviparus intertextus illinoisensis

When we compare the mussel fauna of the rivers of different size, we find that the larger rivers have a greater number of species than the smaller rivers. This is probably due to the greater variety of environments for the adult mussel and the larger number of species of fish hosts for the glochidia. The two species that seem to be restricted to small rivers and streams are *Anodontoides ferussacianus* and *Lasmigona compressa. Amblema costata* and *Fusconaia flava* are found only in small and medium sized rivers, but closely related species, *Amblema rariplicata* and *Amblema peruviana, Fusconaia undata* and *Fusconaia ebenus* are found in large rivers. Several species *(Arcidens confragosus. Carunculina parva, Leptodea fragilis, Quadrula metanevra, Tritogonia verrucosa, Truncilla truncata)* have apparently never migrated beyond the larger rivers in Minnesota although they are found in both small and large rivers in states farther south. The two most widespread species are *Anodonta grandis* and *Lampsilis siliquoidea* which were found in rivers of all sizes and also in lakes. Other species which were found in small, medium and large rivers are *Lampsilis ventricosa, Lasmigona complanata, Ligumia recta latissima,* and *Strophitus rugosus. Actinonaias carinata* and *Proptera alata megaptera* were found in small rivers in the St. Croix drainage, but elsewhere were species of medium-sized and large rivers.

The species of snails found in rivers can be divided into two groups, those which were found only in rivers, and those which were found in lakes and ponds as well. Most of the members of the first group breathe by gills and were found where the current was fairly swift. The only common example of this group is *Pleurocera acuta tracta* which was found in many of the large

and medium-sized rivers of the Mississippi drainage. It is the only member of the Pleuroceridae found in Minnesota. The species *Amnicola emarginata, Amnicola integer, Lioplax subcarinata, Lymnaea catascopium, Physa michiganensis, Somatogyrus subglobosus,* and *Somatogyrus tryoni,* also restricted to rivers, have been found only once or twice. *Physa integra,* although found in both lakes and streams, was more common in streams. Members of the second group, *Amicola limosa, Campeloma decisum, Ferrissia parallela, Ferrissia tarda, Gyraulus parvus, Gyraulus deflectus obliquus, Helisoma antrosa, Helisoma campanulata, Helisoma trivolvis, Lymnaea caperata, Lymnaea megasoma, Lymnaea modicella, Lymnaea stagnalis appressa, Physa gyrina, Planorbula armigera,* and *Valvata tricarinata* were not restricted to rivers, but were found as often in lakes and ponds, and were either found close to where the stream entered or left the lake, or were found in the shallow edges of the river which were stagnant and pond-like. In general the larger rivers contain more of the species which are restricted to a river habitat while the streams and smaller rivers contain more of those species which can live either in standing or flowing waters.

Standing waters have been classified into five groups on the basis of size, total alkalinity, and flow of water.

Habitat 5. PONDS

While there is no sharp distinction between a large pond and a small lake, any shallow body of water less than an acre in area with a mucky, weedy bottom is considered a pond. They usually become smaller or dry up completely in midsummer, and they freeze solid in winter. Minnesota ponds have been studied mainly in three regions. The first is Itasca Park where George Klak in the summer of 1936 collected mollusks in 33 ponds and turned them over to the writer for identification. These ponds were mainly coniferous forest pools and the most common species found were *Aplexa hypnorum, Gyraulus parvus* and *Lymnaea exilis.* This is almost the only habitat for *Aplexa hypnorum* in Minnesota although in other states it may be found near springs and on the walls of wet, shady ravines. It seems to require shade and can endure drought. In addition mollusks were collected by the writer from nine ponds in the region near St. Paul and Minneapolis and from about the same number near Hibbing in St. Louis County. These ponds were either roadside ditches or located in meadows with few if any trees around them. The most common species were *Helisoma trivolvis* and *Physa gyrina.*

No mussels were found in Minnesota ponds, but the three genera of Sphaeriidae, Sphaerium, Musculium, and Pisidium, were common. The following is a complete list of the snails found:

Aplexa hypnorum
Gyraulus parvus
Helisoma trivolvis
Lymnaea caperata
Lymnaea exilis
Lymnaea megasoma
Lymnaea modicella
Lymnaea palustris
Lymnaea reflexa
Menetus exacuous megas
Planorbula armigera
Physa gyrina

All of these species are lung breathing. Since they do not depend on dissolved oxygen in the water, but come to the surface to breathe, they are more suited to shallow stagnant water. Usually not more than three species of snails were found in any one pond.

Habitat 6. SOFT-WATER LAKES

Soft-water lakes ranging in total alkalinity from 7.5 to 75 parts per million are found in the northeastern part of Minnesota in the Rainy River and St. Lawrence drainages. Drainage is poor in this region and lakes are numerous and of different sizes. Those in which mollusks have been collected are principally of two types—they have either a rocky or a sandy shoreline. Lake Vermillion and Sturgeon Lake, both in St. Louis County northwest of Lake Superior are the two lakes which have been studied most extensively.

Lake Vermillion, a large, irregularly shaped lake with an area of 37,915 acres and a total alkalinity of 25 parts per million has a rocky shoreline. Mollusks were collected in this lake in 1881 by U. S. Grant, in 1927 by F. C. Baker, and in 1939 and 1940 by the writer and also by a survey crew from the Minnesota Department of Conservation. Sturgeon Lake is smaller, with an area of 1659 acres, and has gently sloping sandy beaches. The total alkalinity is about 35 parts per million. Extensive collecting was done in this lake by the writer during the four years between 1938 and 1942.

The following mollusks were found in these two lakes:

Mussels	Lake Vermilion	Sturgeon Lake
Anodonta grandis	x	x
Anodonta kennicotti	x	–
Anodonta marginata	x	rare
Lampsilis siliquoidea	x	x
Snails		
Amnicola limosa	x	x
Campeloma decisum	–	x
Ferrissia parallela	x	x
Ferrissia tarda	x	–
Gyraulus deflectus obliquus	x	x
Helisoma antrosa	x	x
Helisoma campanulata	x	x
Helisoma corpulenta vermilionensis	x	–
Lymnaea haldemani	x	x
Lymnaea megasoma	x	–
Lymnaea stagnalis appressa	x	–
Lymnaea stagnalis lillianae	x	–
Menetus exacuous megas	x	x
Physa gyrina	x	x
Planorbula armigera	x	x
Planorbula crassilabris	x	–
Valvata tricarinata	x	x

In spite of the low total alkalinity of the lakes in this area, many of them contain large numbers of mussels, usually *Lampsilis siliquoidea* and one or two species of *Anodonta*. It is difficult to state just what the relationship is between the total alkalinity of a lake and the number of mussels produced. In some of the lakes, such as Clearwater Lake, St. Louis County, with a

total alkalinity of 15 parts per million there were no mussels. In others near by, such as Rock Lake, 20 parts per million, and Robinson Lake 22.5 parts per million, mussels were plentiful. It would seem that unless the total alkalinity is very low, it is not the limiting factor in determining the presence of mussels in a lake. Most of the species of snails found in these soft-water lakes were found also in hard-water lakes and sometimes in ponds or rivers. *Helisoma corpulenta* is restricted to the northern part of the state, but not to soft-water lakes, as it was abundant in Lake Itasca, a medium-hard-water lake described in the next group. *Campeloma decisum*, which was found in both lakes and rivers, was more abundant in soft-water lakes than in lakes with a higher total alkalinity.

Habitat 7. MEDIUM-HARD-WATER LAKES

Most of the lakes in the central part of Minnesota in the Mississippi drainage belong in this category. The total alkalinity varies from 75 to 175 parts per million. Two lakes that have been studied in detail from this area are Lake Itasca in Clearwater County in the north central part of Minnesota, and Snail Lake just north of St. Paul in Ramsey County. Lake Itasca is a Y-shaped lake with an area of 1,152 acres and a total alkalinity of 165 parts per million. Its outlet is the beginning of the Mississippi River. The shore of the lake is either sand or mud and is filling in with wild rice and bulrushes. The University of Minnesota Biological Station is located in Itasca Park, and consequently the mollusks in the lake have been thoroughly studied. Snail Lake near St. Paul, 200 miles south of Lake Itasca, a small lake of 155 acres, has a total alkalinity of about 165 parts per million. Most of the bottom and much of the shore is mucky and filled with weeds, but at one end is a shallow sandy beach where snails are plentiful. The writer explored various parts of the lake during 1939 and 1940.

The following mollusks were found in these two lakes:

Mussels	Lake Itasca	Snail Lake
Anodonta grandis	x	–
Anodonta marginata	x	x
Anodontoides ferussacianus	x	–
Lampsilis siliquoidea	x	–
Snails		
Amnicola limosa	x	x
Amnicola lustrica	x	–
Ferrissia tarda	x	–
Gyraulus deflectus obliquus	x	–
Gyraulus hirsutus	x	–
Helisoma antrosa	x	x
Helisoma campanulata	x	x
Helisoma corpulenta	x	–
Helisoma trivolvis	x	x
Lymnaea exilis	–	x
Lymnaea stagnalis appressa	x	x
Menetus exacuous megas	x	–
Physa gyrina	x	x
Physa integra	–	x
Planorbula armigera	x	–
Valvata lewisi	x	–
Valvata tricarinata	x	–

There were many more mussels in Lake Itasca than in Snail Lake, possibly because of its larger size or because its beaches suffer less from human disturbances. It is generally true that it is easier to find mussels in the more isolated lakes than in those close to the more populous area around St. Paul and Minneapolis. Snails were abundant in both lakes and many of the most common species were common also in soft-water lakes. Perhaps the most striking feature was the number and variety of the planorbid snails. In Lake Itasca all nine of the species of the family Planorbidae common in Minnesota were present.

Habitat 8. HARD-WATER PRAIRIE LAKES

These lakes are found in the western part of Minnesota in the region drained by the Red River, the Minnesota River, and the western tributaries of the upper Mississippi. The lakes vary in size but are often large and shallow. The total alkalinity varies from 150 to 300 parts per million and the water often contains other salts in addition to calcium salts. No lake of this group has been studied extensively, but in the summer of 1940 the writer spent a week collecting in this area. The lakes were very low that summer due to a series of dry years, and in many lakes there was a wide stretch of exposed beach covered with mussel shells. A combined list of mollusks found in lakes in Pope, Ottertail, and Todd Counties gives the following:

Mussels
Anodonta grandis
Lampsilis siliquoidea

Snails
Amnicola limosa
Gyraulus deflectus obliquus
Helisoma antrosa
Helisoma campanulata
Helisoma trivolvis
Lymnaea emarginata
Lymnaea emarginata canadensis
Lymnaea emarginata angulata
Lymnaea palustris
Lymnaea stagnalis appressa
Lymnaea stagnalis lillianae
Physa gyrina
Valvata tricarinata

As in the previous groups *Amnicola limosa, Valvata tricarinata,* the three species of *Helisoma,* and *Lymnaea stagnalis appressa* were common. *Physa gyrina,* although present, was noticeably less abundant than in other parts of the state, and *Campeloma decisum* and *Anodonta marginata* were missing entirely. But most striking of all was the abundance and variety of the larger Lymnaeidae. Two varieties of *Lymnaea stagnalis* and at least two varieties of *Lymnaea emarginata,* as well as *Lymnaea palustris* were present in large numbers in these lakes. There was much variation in these three species in these lakes agreeing with Baker (1936) who stated of *L. emarginata* "Almost every large lake has its own peculiar form which is often quite distinct from the same species from nearby lakes."

Habitat 9. RIVER LAKES

River lakes are lakes in which there is at least a slight current due to their being a part of a river system. They are of two kinds: 1) true river-lakes like Lake Pepin or Lake St. Croix which are simply widenings of a river behind a natural or artificial barrier, and in which the river influence is strong, and 2) lakes with a good sized river for an inlet and outlet, but in which the lake influence predominates. Examples of the second class are Lake of the

Woods and other border lakes in the Rainy River, Cass Lake, Lake Bemidji and Lake Winnibigoshish in the upper Mississippi River, and Cross Lake and Lake Pokegama in the Snake River.

One effect of close relationship with a river system is an increase in the number of species of mussels. The thirty-five species of mussels in Lake Pepin and the fourteen in Lake St. Croix (Tables 2, 4) were the same as those in the Mississippi and St. Croix Rivers respectively. The following snails were found in these two river-lakes:

Amnicola limosa
Campeloma decisum
Helisoma antrosa
Helisoma trivolvis
Lioplax subcarinata
Lymnaea exilis
Physa gyrina
Planorbula armigera
Pleurocera acuta tracta
Valvata tricarinata

The effect of the river is shown in the presence of *Pleurocera* and *Lioplax*, typical river snails. This, together with the large number of species of mussels proves that this type of river-lake is more like a river than a lake in its molluscan fauna.

The second type of river-lake is more like a lake than a river, but the effect of having a good sized river for inlet and outlet is to increase the number of species of mussels. In most Minnesota lakes with little or no river connections, the mussels found were limited to *Lampsilis siliquoidea, Anodonta grandis, Anodonta marginata,* and *Anodontoides ferussacianus,* and usually not more than two species were found in any one lake. The following species were found in three of the second type of river-lake:

	Lake Pokegama	Cross Lake	Lake of the Woods
Mussels			
Amblema rariplicata	x	x	–
Anodonta grandis	x	–	x
Anodonta marginata	–	–	x
Actinonais carinata	–	x	–
Fusconaia undata	x	x	–
Lasmigona complanata	–	–	x
Lampsilis siliquoidea	x	x	x
Lampsilis ventricosa	x	x	–
Leptodea fragilis	–	x	–
Ligumia recta latissima	–	x	x
Proptera alata megaptera	–	x	–
Quadrula pustulosa	x	–	–
Quadrula quadrula	x	x	–
Strophitus rugosus	x	–	–
Snails			
Amnicola limosa	x	x	–
Campeloma decisum	–	–	x
Gyraulus deflectus obliquus	–	–	x
Helisoma antrosa	x	–	x
Helisoma campanulata	x	–	x
Helisoma trivolvis	x	–	x
Lymnaea exilis	x	–	–
Lymnaea emarginata	–	–	x
Lymnaea palustris	–	–	x

Lymnaea stagnalis appressa	–	–	x
Physa gyrina	–	–	x
Planorbula armigera	x	–	–
Valvata tricarinata	x	x	x

The typical river snails, *Pleurocera* and *Lioplax*, were not found in these lakes, and many typical lake species, i.e. *Helisoma campanulata, Lymnaea stagnalis appressa, Amnicola limosa,* and *Valvatat tricarinata* were found. (The small number of snails reported from Cross Lake is probably due to lack of collecting in that lake.) It would seem that in this type of river-lake the number of species of mussels is increased due to its close relationship to a river, but that the snail population is not noticeably affected.

Distribution of Individual Species

Below is a list of the 45 species of mussels found in Minnesota with a brief summary of the geographical and ecological distribution of each.

Subfamily UNIONINAE

1. *Fusconaia flava* (Rafinesque).—in the Red River and St. Croix River systems, in streams and small rivers.

2. *Fusconaia undata* (Barnes).—in the St. Croix and Minnesota Rivers and in the Mississippi River south of St. Anthony Falls, restricted to large rivers and river lakes. It is the most common species of Fusconaia in Minnesota.

3. *Fusconaia ebenus* (Lea).—in the Mississippi River south of St. Anthony Falls, apparently a large river species. It has not been seen for some years and may be extinct in Minnesota.

4. *Megalonaias gigantea* (Barnes).—in the lower Minnesota and St. Croix Rivers, and in the Mississippi River south of St. Anthony Falls, apparently confined to large rivers.

5. *Amblema peruviana* (Lamarck).—in the lower Minnesota and St. Croix Rivers and Mississippi River south of St. Anthony Falls, a species confined to large rivers.

6. *Amblema rariplicata* (Lamarck).—in the Minnesota and St. Croix Rivers and in two river-lakes in the St. Croix drainage, apparently a species of medium-sized rivers.

7. *Amblema costata* (Rafinesque).—in the Cedar River, a tributary of the lower Mississippi, in the Kettle, Snake and Sunrise Rivers, tributaries of the St. Croix, and in the Red River drainage, apparently confined to small rivers.

8. *Quadrula quadrula Rafinesque*.—in the Red and Minnesota Rivers and in the Mississippi south of St. Anthony Falls, a species of large rivers.

9. *Quadrula pustulosa* (Lea).—in the Mississippi River south of St. Anthony Falls, and in the Minnesota and St. Croix Rivers, all large rivers.

10. *Quadrula metanevra* (Rafinesque).—only in the Mississippi River south of St. Anthony Falls, the largest river in Minnesota.

11. *Tritogonia verrucosa* (Rafinesque).—in the Mississippi River south of St. Anthony Falls and in the Minnesota and St. Croix, all large rivers.

12. *Cyclonaias tuberculata* (Rafinesque).—in the Mississippi River south of St. Anthony Falls and in the St. Croix River, not found in large numbers anywhere.

13. *Plethobasus cyphyus* (Rafinesque).—in the Mississippi River below Lake Pepin where it was abundant at ane time, and in the Minnesota and St. Croix Rivers where it is apparently rare.

14. *Pleurobema cordatum coccineum* (Conrad).—in the St. Croix River, and the Snake River, one of its tributaries, in Lake Pepin and in the Minnesota River, but not abundant anywhere.

15. *Elliptio dilatatus* (Rafinesque).—in the Mississippi River south of St. Anthony Falls, in the Minnesota and St. Croix Rivers, restricted to large rivers except in the St. Croix, and abundant where found.

16. *Elliptio crassidens* (Lamarck).—in the Mississippi River south of St. Anthony Falls, and in the Minnesota River, restricted to large rivers and comparatively rare.

17. *Elliptio complanatus* (Dillwyn).—in Lake Superior, found in large numbers on Minnesota Point in Duluth.

Subfamily ANODONTINAE

18. *Lasmigona compressa* (Lea).—widespread and abundant in streams and small rivers of the Mississippi drainage north of St. Anthony Falls and also found in the St. Croix, St. Louis, and Rainy River drainages.

19. *Lasmigona costata* (Rafinesque).—in the Mississippi River south of St. Anthony Falls, and in the Snake River and Red Lake River, being found in medium-sized as well as large rivers.

20. *Lasmigona complanata* (Barnes).—in small medium, and large rivers of the Mississippi drainage south of St. Anthony Falls, the Minnesota, St. Croix, Hudson Bay and St. Lawrence drainages as well as in Lake of the Woods and Lake Superior.

21. *Anodonta grandis* Say.—in both lakes and rivers in all parts of Minnesota. Special lake and river varieties can sometimes be distinguished. It is one of the most common species in Minnesota.

22. *Anodonta gigantea* Lea.—sometimes considered a variety of *A. grandis*, in the Mississippi River south of St. Anthony Falls and in the Minnesota River, restricted to large rivers.

23. *Anodonta kennicotti* Lea.—in several large lakes in the northern part of the state. It is rare.

24. *Anodonta marginata* Say.—in many lakes in northern Minnesota in the Mississippi, Hudson Bay, and St. Lawrence drainages.

25. *Anodonta corpulenta* Cooper.—in the Mississippi River south of St. Anthony Falls, in the Minnesota and St. Croix Rivers, apparently restricted to large rivers and not common.

26. *Utterbackia imbecillis* (Say).—in the Mississippi, Minnesota and St. Croix Rivers, often in lake-like areas. It surmounted the barrier of St. Anthony Falls but has never been found north of Anoka, about twenty miles above the Falls.

27. *Anodontoides ferussacianus* (Lea).—in all parts of the state in small tributary and headwater streams, and also in lakes, especially in the northern part. It is common and widespread in Minnesota.

28. *Alasmidonta marginata truncata* (B. H. Wright).—in the Mississippi River south of St. Anthony Falls, the Minnesota River, and the Sunrise and Snake Rivers. Not common, but found in both small and large rivers.

29. *Arcidens confragosus* (Say).—in the Mississippi River south of St. Anthony Falls and in the Minnesota River, restricted to the largest rivers in Minnesota and not common.

30. *Strophitus rugosus* (Swainson).—in small rivers in the St. Croix and Red River systems, and in the Mississippi River south of St. Anthony Falls, not common but found in both small and large rivers.

Subfamily LAMPSILINAE

31. *Obliquaria reflexa* Rafinesque.—in the Mississippi River south of St. Anthony Falls, and in the Minnesota, St. Croix, and Red Rivers, widely distributed but not abundant.

32. *Obovaria olivaria* (Rafinesque).—in the Mississippi River south of St. Anthony Falls and in the Minnesota and St. Croix Rivers, large and medium sized rivers, not common.

33. *Actinonaias carinata* (Barnes).—in all parts of the Mississippi drainage and in the Hudson Bay drainage, widely distributed in medium sized and large rivers, but not present in large numbers.

34. *Truncilla truncata* Rafinesque.—in the Mississippi River south of St. Anthony Falls, and in the Minnesota and St. Croix Rivers, all large rivers.

35. *Truncilla donaciformis* (Lea).—in the Mississippi River at Red Wing and in the Minnesota River at Fort Snelling, a rare species and limited to the largest rivers in the state.

36. *Plagiola lineolata* (Rafinesque).—in the Mississippi River south of St. Anthony Falls and in the Minnesota River, confined to large rivers and not common.

37. *Leptodea fragilis* (Rafinesque).—in the Mississippi River south of St. Anthony Falls, in the Minnesota and St. Croix Rivers and in Cross Lake, apparently confined to large rivers and river-lakes.

38. *Proptera alata megaptera* (Rafinesque).—in the Mississippi River south of St. Anthony Falls, the Minnesota, St. Croix and Red River drainages, in both large and medium-sized rivers.

39. *Proptera laevissima* (Lea).—in the Mississippi River south of St. Anthony Falls and in the Minnesota and St. Croix Rivers, a rare species limited to large rivers.

40. *Carunculina parva* (Barnes).—abundant in Lake Pepin, found also in the St. Croix and Minnesota Rivers.

41. *Ligumia recta latissima* (Rafinesque).—in all drainages, common in all but the smallest rivers and found also in Lake of the Woods and Lake Superior.

42. *Lampsilis fallaciosa* (Smith) Simpson.—in the Mississippi River south of St. Anthony Falls and the Minnesota River at Fort Snelling, restricted to large rivers.

43. *Lampsilis siliquoidea* (Barnes).—in rivers and lakes in all parts of the state, not restricted to any stream type but showing growth forms or varieties in lakes and rivers.

44. *Lampsilis ventricosa* (Barnes).—in all parts of the Mississippi drainage, in the Hudson Bay drainage, and in Lake Superior, common in small, medium, and large rivers.

45. *Lampsilis higginsii* (Lea).—in the Mississippi River south of St. Anthony Falls, and in the Minnesota and St. Croix Rivers, not common and restricted to large rivers.

Below is a list of snails found in Minnesota with a brief statment of the distribution of each.

Family VALVATIDAE

1. *Valvata tricarinata* (Say).—common in lakes in all parts of the state, on shallow, sandy beaches, or on vegetation, more rare in streams connected with lakes.

2. *Valvata sincera* Say.—reported by Daniels from Cannon Lake in Rice County and by Goodrich from Medicine Lake in Hennepin County.

3. *Valvata lewisi* Currier.—in Lake Itasca and several other lakes in the northern and eastern parts of the state, not common.

Family VIVIPARIDAE

4. *Viviparus intertextus illinoisensis* Baker.—in the Mississippi River near Winona and in White Bear Lake and a few other connecting lakes and streams in Ramsey County.

5. *Lioplax subcarinata* (Say).—in Lake Pepin and in the Minnesota River at Fort Snelling, limited apparently to large rivers.

6. *Campeloma decisum* (Say).—common in lakes and rivers in the northern, eastern and central parts of the state where the waters have a low total alkalinity. Often found buried in mud of river banks or in sand of lake shores. Most of the Campelomas found in the state are considered to belong to this species, but *Campeloma subsolidum* was reported by Goodrich in the southern part of the state in a lagoon off the Mississippi River.

Family AMNICOLIDAE

7. *Amnicola limosa* (Say).—common in lakes throughout the state, usually attached to vegetation, and also found in some rivers where the current is slow and there is attached vegetation.

8. *Amnicola lustrica* Pilsbry.—in a few lakes in the central part of the state, attached to vegetation.

9. *Amnicola integer* Say.—in three rivers: Rum River in Anoka County, Rainy River on the Canadian border, and the Minnesota River at Fort Snelling, in shallow water attached to gravel and small stones.

10. *Amnicola emarginata* (Kuster).—in the Minnesota River at Fort Snelling (1885).

11. *Somatogyrus tryoni* Pilsbry and Baker.—in the St. Croix River at Marine, collected from rocks at water's edge (1939).

12. *Somatogyrus subglobosus* (Say).—in the Kettle River and in the Minnesota River on mud flats.

Family PLEUROCERIDAE

13. *Pleurocera acuta tracta* (Anthony).—in many parts of the Mississippi, Minnesota, and St. Croix Rivers and their tributaries, common in large and medium sized, and rare in smaller rivers, it is the most common river snail in Minnesota.

Family LYMNAEIDAE

14. *Lymnaea stagnalis appressa* Say.—in many lakes throughout the state, in large numbers on shallow, sandy beaches. Especially common in northern and eastern parts. Also found in a few streams, usually inlets or outlets of lakes. Two other varieties, *L. stagnalis lillianae* Baker and *Lymnaea stagnalis perampla* Walker were occasionally found in large lakes.

15. *Lymnaea palustris* Müller.—in western and southern parts of the state in ponds, lakes, and slow-moving edges of rivers.

16. *Lymnaea umbrosa* Say.—in several lakes in the state, rare.

17. *Lymnaea reflexa* Say.—in a few lakes and ponds in central and southern Minnesota, also rare.

18. *Lymnaea exilis* Lea.—in many ponds and a few lakes in the northern, eastern and central parts of Minnesota, sometimes present in large numbers, especially in ponds.

19. *Lymnaea emarginata* Say.—and the two varieties *L. emarginata angulata* (Sowerby) and *L. emarginata canadensis* (Sowerby) in many large lakes in western and northern Minnesota, seems especially adapted to large, hard-water lakes.

20. *Lymnaea lanceata* Gould.—in two lakes in the northern part of the state.

21. *Lymnaea walkeriana* (Baker).—from the north shore of Lake Superior.

22. *Lymnaea woodruffi* (Baker).—from two lakes on the Canadian border.

23. *Lymnaea catascopium* Say.—from the Rum River, Anoka County.

24. *Lymnaea caperata* Say.—from lakes, ditches, ponds, and small streams, often filled with vegetation and drying up in summer.

25. *Lymnaea haldemani* Deshayes, Binney.—in several lakes in central and northern Minnesota, usually found attached to sticks or rushes, often found in only one spot in a lake, and probably easily overlooked.

26. *Lymnaea megasoma* Say.—in central and northern Minnesota, in parts of lakes, ponds, and rivers where vegetation is abundant and the bottom mucky.

27. *Lymnaea humilis modicella* (Say).—in central and eastern Minnesota on edges of rivers, lakes, and ponds especially on flat muddy beaches that are drying up.

28. *Lymnaea obrussa* Say.—in central, eastern and north central Minnesota, in lakes or ponds, sometimes on water plants and sometimes on the bottom. The variety *L. obrussa decampi* Streng was found in two lakes in the central part of the state.

Family PLANORBIDAE

29. *Helisoma antrosa* (Conrad).—in all parts of Minnesota in both lakes and rivers, very common. One very distinct variety, *H. antrosa royalensis* Walker, was found in a few northern lakes.

30. *Helisoma trivolvis* (Say).—in all parts of Minnesota, in lakes, ponds, and rivers, often in thick masses of water plants. The large, high variety, *H. trivolvis pilsbryi* (Baker) was found in a few northern lakes.

31. *Helisoma corpulenta* (Say).—in many northern lakes, both in the upper Mississippi and Hudson Bay drainages. The variety *H. corpulenta vermilionensis* (Baker) has been found only in Lake Vermilion.

32. *Helisoma campanulata* (Say).—in lakes in all parts of the state, very common both alive and as a white dead shell in beach debris.

33. *Planorbula armigera* (Say).—in the stagnant parts of lakes, ponds, and rivers in all parts of the state.

34. *Menetus exacuous megas* (Dall).—in lakes in all parts of the state, attached to sticks or larger floating wood.

35. *Gyraulus hirsutus* (Gould).—in a few lakes in northern Minnesota.

36. *Gyraulus deflectus obliquus* (DeKay).—in lakes in central and north central Minnesota.

37. *Gyraulus parvus* (Say).—in northern and central Minnesota, in lakes, ponds or streams attached to aquatic plants, especially common on the under side of water-lily leaves.

38. *Gyraulus umbilicatellus* (Cockerell).—from the central and northern part of the state in lakes and ponds.

39. *Gyraulus circumstriatus* (Tryon).—reported by F. C. Baker from North Star Lake in Itasca County.

40. *Gyraulus altissimus* (Baker).—reported by F. C. Baker from North Star Lake in Itasca County.

41. *Gyraulus crista* (Linneus).—reported by F. C. Baker from North Star Lake in Itasca County.

Family ANCYLIDAE

42. *Ferrissia parallela* (Haldeman).—attached to water plants in rivers and lakes

in widely separated parts of Minnesota, probably easily overlooked because of its small size.

43. *Ferrissia tarda* (Say).—attached to shells or sticks in lakes in central and northern Minnesota.

44. *Ferrissia rivularis* (Say).—reported once or twice mainly from northern lakes and rivers.

45. *Ferrissia fusca* (Adams).—reported once or twice mainly from northern lakes or rivers.

Family PHYSIDAE

46. *Physa gyrina* Say.—in all parts of the state, and in all kinds of habitats, the most common species of *Physa* in the state.

47. *Physa sayii* Tappan.—in several large lakes in different parts of the state.

48. *Physa integra* Haldeman.—in many parts of Minnesota in streams and lakes, but more often in streams.

49. *Physa laphami* (Baker).—in two northern lakes, rare.

50. *Physa michiganensis* Clench.—in a stream near Minneapolis.

51. *Aplexa hypnorum* (Linneus).—in temporary pools in coniferous forests especially in the northern part of the state.

Summary

The distribution of mollusks is influenced by both geographical and ecological factors. The separation of one drainage system from another, and barriers such as water-falls within a single drainage serve to limit the geographical distribution of mussels. Snails can surmount such barriers more easily. Ecological factors, such as size, current, chemical content, kind of bottom, and presence of vegetation are important in the distribution of both snails and mussels.

The three drainage systems in Minnesota are described and the mussels in each are listed. The largest number of species was found in the Mississippi River south of St. Anthony Falls which has apparently proved a barrier to the Northward migration of many of these species since only eight were found above the falls while 27 species were found at Fort Snelling a few miles below and 20 species were found in the upper St. Croix drainage. The rivers of the St. Lawrence drainage had the smallest number of species. Most species of mussels in Minnesota apparently migrated into the state from the lower Mississippi River after the retreat of the glacier, but *Anodonta marginata*, found in many northern lakes, and *Elliptio complanatus*, found only in Lake Superior in Minnesota are species characteristic of the St. Lawrence drainage and apparently have come in through the Great Lakes. There is a similarity between the mussels of the Minnesota and Red Rivers which is explained by their long post-glacial connection.

The waters of Minnesota are divided ecologically into flowing waters and standing waters. The flowing waters are further subdivided into small creeks, small rivers, medium-sized rivers, and large rivers, and the standing waters into ponds, soft-water lakes, medium-hard lakes, prairie hard-water lakes, and river-lakes. The mollusks in each are listed.

Although some species of mussels, such as *Lampsilis siliquoidea* and *Anodonta grandis* can live in a wide variety of habitats, most species are adapted to a more or less limited environment. *Anodonta marginata* was found only in lakes, *Anodontoides ferussacianus* only in lakes and small rivers, *Lasmigona compressa* only in small rivers. *Amblema costata, Fusconaia flava,* and *Strophitus rugosus* also seemed to prefer small rivers. Several species were found only in larger rivers in Minnesota, although farther south they were found also in medium-sized and even small rivers.

Most snails found in lakes, ponds, and even in small rivers were lung breathing and belonged to the Order Pulmonata, although a few gill-breathing snails of the Order Ctenobranchiata, such as *Valvata tricarinata, Amnicola limosa,* and *Campeloma decisum* were common in large lakes. Most of the snails found only in rivers were gill-breathing, the most common one being *Pleurocera acuta tracta.* Only lung-breathing snails were found in Minnesota ponds, and usually not more than three different species in any one pond. *Aplexa hypnorum, Gyraulus parvus,* and *Lymnaea exilis* were the most common species in the more or less temporary coniferous forest pools of Itasca Park, while *Helisoma trivolvis* and *Physa gyrina* were more common in the less shaded and more permanent ponds in other parts of the state. In lakes the common species were *Amnicola limosa, Helisoma antrosa, Helisoma campanulata, Lymnaea stagnalis appressa, Physa gyrina,* and *Valvata tricarinata. Campeloma decisum* was common in soft-water and medium-hard lakes, while in the prairie hard-water lakes in the western part of the state *Lymnaea palustris* and *Lymnaea emarginata* were abundant and varied. In river-lakes the river influenced the molluscan fauna in two ways—the number of species of mussels increased and the snails *Pleurocera acuta tracta* and *Lioplax subcarinata* appeared.

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THE WOMAN'S COLLEGE OF THE
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A Check List of the Known Species of North American Freshwater Ostracoda*

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Nearly thirty years have elapsed since the publication of the last complete list of freshwater ostracodes of North America (Sharpe, 1918). Since then considerable work has resulted in records of many species hitherto unknown on this continent and many new species have been described. In an attempt to bring together the known species of this group and as a preliminary step in the work on a *Handbook of North American Freshwater Ostracoda*, the present paper is offered. The author will greatly appreciate additions and corrections from other workers in the field.

Ostracoda have been very thoroughly studied in Europe and are well known. Work on this group in North America has been greatly neglected and and only a comparatively few papers have been published since the first description of ostracodes in this country was published over 100 years ago. Two new species of "Cypris" were described from Pennsylvania in 1841 in the first volume of the *Proceedings of the Academy of Natural Science of Philadelphia* by S. S. Haldemann (Haldemann, 1841). In two papers published the following year (Haldeman, 1842a and 1842b), this author described two more species of "Cypris" from Pennsylvania and Massachusetts. By the year 1886, only fifteen species of ostracodes had been reported from North America. In that year, Underwood published a list of the described species of freshwater crustacea from North America, north of Mexico (Underwood, 1886). Thirteen years later, largely through the efforts of Herrick and of Turner, forty species of freshwater ostracodes were known from this continent and were included in *A Synopsis of Freshwater Invertebrates of North America* (Turner, 1899). Fifteen years now elapsed before the next attempt at a complete list of the group was published. In 1914, Weckel published a paper entitled *Free-swimming Freshwater Entomostraca of North America* (Weckel, 1914), in which forty-four species of ostracodes were given, together with keys for identifying them.

The last complete synopsis of North American ostracodes was published by Sharpe in 1918 in Ward and Whipple's *Freshwater Biology* (Sharpe, 1918). Sharpe listed and gave brief descriptions of fifty-four species, some of them dubious. Since that date, largely due to the work of Furtos, Hoff, Dobbin and Rioja, many new additions have been made to the known forms of this group. In 1933, Furtos published *The Ostracoda of Ohio* and brought the total number of known species to eighty-eight (Furtos, 1933). Dobbin (1941) added twelve new species or new records, bringing the total to an even 100. Hoff (1942) in his *Ostracods of Illinois* added eleven new species. Since 1942, several papers have been contributed by Hoff and Rioja. An

* A contribution from the Zoology Department of the University of Maryland. College Park, Maryland.

interesting aspect of the work of these two investigators has been the uncovering of some fifteen or more species belonging to the little known parasitic genus *Entocythere*, first established in 1903 by William S. Marshall, with the description of one species parasitic on the gills of freshwater crayfish.

The present paper attempts to include all the species listed by the workers named above and in addition has added a number of new records for the continent from the author's work on this group during the past twenty years. A total of 204 species are listed; those with records marked (Tressler) with no date, are records of species identified by the author for various people and the United States National Museum and which have not been included in published reports.

The present distribution of the North American freshwater ostracodes is so imperfectly known that a wide open field awaits the future investigator and new records for previously restricted genera are being added every year. Evenson, for example in 1942, first reported in the United States the presence of the large *Chlamydotheca unispinosa* from Illinois. Since then it has been reported from several locations in the United States including Louisiana and Maryland. Long believed to be a tropical form, its actual distribution has been shown to considerably exceed the original known range.

The taxonomy and classification in the present paper is largely that of G. W. Müller as given in his classical treatise on the *Ostracoda* in *Das Tierreich* (1912). The record is believed to be complete through December, 1946.

Suborder **Podocopa**

Family CYPRIDAE

Subfamily CANDONINAE

Genus *Cyclocypris*

C. ampla Furtos—Ohio (Furtos 1933); Massachusetts (Furtos 1935).

C. cruciata Furtos—Massachusetts (Furtos 1935).

C. forbesi Sharpe—Illinois (Sharpe 1918, Hoff 1942); Massachusetts (Furtos 1935).

C. globosa Sars—Northwest Territory (Sars 1926).

C. laevis (O. F. Müller)—Delaware, Indiana, Illinois, New York, New Jersey (Sharpe 1918); Massachusetts (Furtos 1935).

C. nahcotta Dobbin—Washington (Dobbin 1941).

C. ovum (Jurine)—Ohio (Furtos 1933); Washington (Dobbin 1941).

C. serena Koch—Montana, Michigan, Pribloff Islands (Tressler).

C. sharpei Furtos—Ohio, Illinois, New York (Furtos 1933); Illinois (Hoff 1942); Florida (Furtos 1936); Louisiana (Hoff 1943d); New Brunswick, Iowa (Tressler).

C. washingtonensis Dobbin—Washington (Dobbin 1941).

Genus *Cypria*

C. dentifera Sharpe—Illinois, Ohio, New York, New Jersey (Sharpe 1918); Maine (Tressler).

C. inequivalva Turner — Ohio, Georgia (Furtos 1933); Georgia (Turner 1893).

C. lacustris—Ontario (Sars 1926); Michigan, Texas (Tressler).

C. maculata Hoff—Georgia, Illinois, Minnesota, Oregon (Sharpe 1918) (?); Illinois (Hoff 1942, 1943a).

C. mediana Hoff—Illinois (Hoff 1942).

C. mons Chambers—Colorado (Chambers 1877) (doubtful form).

C. obesa Sharpe—Illinois (Sharpe 1897, Hoff 1942, 1943a); Ohio, Illinois (Furtos 1933); D. C. (Tressler).

C. opthalmica Jurine—Georgia (Turner 1896); Illinois (Hoff 1942, 1943a); Tennessee (Hoff 1942); Washington, Alaska (Dobbin 1941); Nova Scotia (Willey 1923); Montana, Florida, Utah (Tressler).

C. pellucida Sars—Ohio (Furtos 1933).

C. palustra Furtos—Massachusetts (Furtos 1935).

C. pseudocrenulata Furtos—Florida (Furtos 1936).

C. turneri (Hoff)—Newfoundland (Alm 1914); Delaware (Turner 1897); Washington, Alaska (Dobbin 1941); Illinois (Hoff 1942, 1943a); Alabama (Herrick 1887); Ohio (Furtos 1933, Turner 1897); Tennessee (Hoff 1943b); Mississippi (Hoff 1943d); Wisconsin, Michigan, Utah, Virginia (Tressler).

Genus *Physocypria*

P. denticulata (Daday)—Yucatan (Furtos 1936).

P. dentifera (Sharpe) — Ohio (Sharpe 1897); New York, New Jersey (Sharpe 1908); Ohio, Illinois (Furtos 1933).

P. exquisita Furtos—Florida (Furtos 1936).

P. fadeewi Dubowsky—Florida (Furtos 1936).

P. gibbera Furtos—Florida (Furtos 1936).

P. inequivalva Turner — Georgia (Turner 1896); Ohio, Georgia (Sharpe 1918).

P. posterotuberculata Furtos—Massachusetts (Furtos 1935).

P. pustolosa (Sharpe 1897) — Ohio (Sharpe 1897, Furtos 1933); Illinois (Furtos 1933, Hoff 1942); Missouri (Ferguson 1944); Alaska, Washington (Dobbin 1941); Massachusetts (Furtos 1935); Florida (Furtos 1936); Mississippi (Hoff 1943d); Louisiana (Hoff 1943d, Tressler); Michigan, Virginia, Oklahoma (Tressler).

P. xanibanica Furtos—Yucatan (Furtos 1936).

Genus *Cyclocypris*

C. kincaidia Dobbin—Washington (Dobbin 1941).

Genus *Candona*

C. acuminata Fischer—Texas (Tressler).

C. acuta Hoff—Illinois (Hoff 1942).

C. albicans Brady — Colorado (Sharpe 1908); Illinois (Hoff 1942); Ohio (Furtos 1933); California (Dobbin 1941).

C. annae Mehes—Massachusetts (Furtos 1935); Florida (Furtos 1936).

C. biangulata Hoff—Illinois (Hoff 1942, 1943a); Florida (Furtos 1936).

C. balatonica Daday—Alaska (Dobbin 1941).

C. candida O. F. Müller — Massachusetts (Sharpe 1918); Oregon (Dobbin 1941); Montana (Tressler).

C. caudata Kaufmann — Illinois (Hoff 1942); Washington (Dobbin 1941); Massachusetts (Furtos 1935); Montana (Tressler).

C. crogmaniana Turner — Georgia (Turner 1894); Ohio, Georgia (Furtos

1933); Illinois (Hoff 1942); Wisconsin, New York, Michigan, Kansas (fossil), (Tressler).

C. decora Furtos—Ohio (Furtos 1933); Massachusetts (Furtos 1935); Michigan (Tressler).

C. delawarensis Turner—Delaware (Turner 1895) (?).

C. distincta Furtos—Ohio (Furtos 1933); Illinois (Hoff 1942, 1943a).

C. elliptica Furtos — Ohio (Furtos 1933); Massachusetts (Furtos 1935); Tennessee (Hoff 1943b); Mississippi (Hoff 1943d).

C. eriensis Furtos—Ohio (Furtos 1933).

C. exilis Furtos—Ohio (Furtos 1933); Michigan (Tressler).

C. faebeformis Fischer — Georgia, Illinois (Sharpe 1918); Pribloff Islands (Tressler).

C. fluviatilis Hoff—Illinois (Hoff 1942).

C. fossulensis Hoff—Illinois (Hoff 1942, 1943a).

C. foveolata Dobbin—Washington (Dobbin 1941).

C. indigena Hoff—Illinois (Hoff 1942, 1943a).

C. intermedia Furtos—Ohio (Furtos 1933); Texas (Tressler).

C. hyalina Brady and Robertson—Lake Superior (Tressler).

C. inopinata Furtos—Ohio (Furtos 1933).

C. ohioensis Furtos—Ohio (Furtos 1933).

C. peircei Turner—Georgia (Turner 1897).

C. parallela G. W. Müller — Ohio, Colorado (Furtos 1933); California (Dobbin 1941); Nova Scotia (Willey 1923).

C. parvula Sars—Ontario (Sars 1926); Quebec (Tressler).

C. punctata Furtos—Ohio (Furtos 1933); Illinois (Hoff 1942); Massachusetts (Furtos 1935).

C. reflexa Sharpe—Illinois (Sharpe 1918); Michigan (Tressler).

C. recticauda Sharpe—Illinois (Sharpe 1897).

C. scopulosa Furtos—Lake Erie (Furtos 1933).

C. sharpei Hoff—Illinois (Hoff 1942).

C. simpsoni Sharpe—Illinois (Sharpe 1918, Hoff 1942, 1943a).

C sigmoides Sharpe—Illinois (Sharpe 1918, Hoff 1942).

C. stagnalis Sars—Ohio (Furtos 1933).

C. subgibba Sars—Alaska (Sars 1926).

C. suburbana Hoff—Illinois (Hoff 1942, 1943a).

C. truncata Furtos—Ohio (Furtos 1933); Michigan (Tressler).

C. ugilinosa Furtos—Ohio (Furtos 1933).

C. marengoensis Klie—Indiana (Klie 1931).

C. jeanneli Klie—Indiana, Kentucky (Klie 1931).

Genus *Paracandona*

P. euplectella Brady and Robertson—Ohio, New Jersey (Furtos 1933).

Genus *Candonopsis*

C. kingsleii Brady and Robertson—Puerto Rico (Tressler 1941).

Subfamily ILYOCYPRINAE

Genus *Ilyocypris*

I. biplictata (Koch)—Texas (Tressler).

I. bradyi Sars—Lake Erie, Ohio, Colorado (Furtos 1933); Colorado (Sharpe 1918); Illinois (Hoff 1942); Wisconsin (Tressler).

I. gibba (Ramdohr)—Colorado (Sharpe 1918); Illinois (Hoff 1942); Ohio (Furtos 1933).

Subfamily CYPRINAE

Genus *Notodromus*

N. monacha O. F. Müller — Minnesota (Herrick 1882); Indiana (Sharpe 1908); Alaska (Dobbin 1941); Illinois (Hoff 1942).

Genus *Cyprois*

C. marginata (Straus) — Illinois (Sharpe 1908); Ohio, Illinois (Furtos 1933); Michigan (Tressler).

C. occidentalis Sars—Ontario (Sars 1926); Washington (Dobbin 1941).

Genus *Cyprinotus*

C. americanus Cushman—Massachusetts (Cushman 1905).

C. aureus (Sars)—Ohio (Furtos 1933).

C. crena Turner—Ohio (Turner 1893).

C. crenatus (Turner)—Ohio (Furtos 1933).

C. dentatus Sharpe — Nebraska (Sharpe 1910); Tennessee (Hoff 1943b); Texas (Tressler).

C. fluviatilis Furtos — Ohio (Furtos 1933); Washington, Arizona, Delaware (Dobbin 1941).

C. fretensis (Brady)—Washington (Dobbin 1941).

C. glaucus Furtos—Lake Erie (Furtos 1933).

C. incongruens (Ramdohr)—Ohio (Turner 1893); Lake Erie, Ohio, Florida, Pennsylvania (Furtos 1933); Florida (Sharpe 1897); Pennsylvania (Sharpe 1908); Greenland (Alm 1914); Oregon (Dobbin 1941); Illinois (Hoff 1942); Quebec, Ontario, Newfoundland (Sars 1926); D.C., Oregon, Wisconsin, North Carolina, Utah, Hudsons Bay (Tressler).

C. inconstans Furtos—Yucatan (Furtos 1936).

C. pellucidus Sharpe—Mexico, Illinois, Washington, Idaho (Sharpe 1918).

C. putei Furtos—Yucatan (Furtos 1936).

C. scytoda Dobbin—California (Dobbin 1941).

C. salinus (Brady)—Texas (Tressler).

C. symmetricus (G. W. Müller)—Yucatan (Furtos 1936).

C. unispinifera Furtos—Yucatan (Furtos 1936).

Genus *Eucypris*

E. affinis hirsuta Fischer—Newfoundland, Alaska (Alm 1914).

E. arcadiae Furtos—Florida (Furtos 1936).

E. cisternina Furtos—Yucatan (Furtos 1936).

E. crassa O. F. Müller—Ontario (Sars 1926, Tressler); Virginia (Tressler).

E. fuscata (Jurine) — Ohio, Illinois, Mexico (Furtos 1933); Massachusetts (Cushman 1907); New York, Massachusetts (Tressler).

E. hystrix—Ohio (Furtos 1933).

E. rara Furtos—Ohio, Illinois (Furtos 1933).

E. reticulata (Zaddach) — Illinois, Massachusetts, New York, New Jersey (Sharpe 1918); Massachusetts (Cushman 1907).

E. serrato-marginata Furtos—Yucatan (Furtos 1936).

E. virens (Jurine)—Wisconsin (Sharpe 1918); Ohio, Massachusetts, Wisconsin, Mexico (Furtos 1933); Mexico (Dobbin 1941); Massachusetts (Cushman 1907).

Genus *Prionocypris*

P. canadensis Sars—Alberta (Sars 1926).

P. longiforma Dobbin—Washington (Dobbin 1941).

Genus *Cypris*

C. altissima Chambers—Colorado (Chambers 1877).

C. grandis Chambers—Colorado (Chambers 1877) (?).

C. pubera (G. W. Müller)—Oregon (Sharpe 1918); Washington (Dobbin 1941); Wyoming, Ontario (Tressler).

C. subglobosa Sowerby—Louisiana, Michigan (Tressler).

Genus *Candonocypris*

C. pugionis Furtos—Florida (Furtos 1936).

C. serrato-marginata (Furtos)—Florida (Furtos 1936).

Genus *Cypriconcha*

C. alba Dobbin—Washington (Dobbin 1941).

C. barbata (Forbes)—Wyoming (Sharpe 1918); Alberta (Sars 1926).

C. gigantea Dobbin—Alaska (Dobbin 1941).

Genus *Chlamydotheca*

C. arcuata (Sars) Ohio, Mexico (Furtos 1933); Florida (Hoff 1944); Louisiana (Tressler).

C. azteka Saussure—Texas, Mexico (Sharpe 1918).

C. flexilis (Brady)—Louisiana (Hoff 1943d).

C. herriki Turner—Ohio (Sharpe 1918).

C. mexicana Sharpe—Mexico (Sharpe 1903).

C. speciosa speciosa Dana—Ohio, Texas (Furtos 1933).

C. texasiensis (Baird)—Yucatan (Furtos 1936); Texas, Louisiana (Tressler).

C. unispinosa (Baird) — Yucatan (Furtos 1936); Illinois (Evenson 1942); Ohio (Hoff 1944); Louisiana, Maryland (Tressler).

Genus *Strandesia*

S. bicuspis bicuspis (Claus)—Yucatan (Furtos 1936); Florida (Hoff 1944).

S. intrepida Furtos—Yucatan (Furtos 1936).

S. obtusata (Sars)—Yucatan (Furtos 1936).

Genus *Cypricercus*

C. affinis Daday—Ohio, Illinois, Mexico (Furtos 1933); Alaska (Sars 1926); Ontario (Sars 1926, Tressler).

C. columniensis Dobbin—Washington (Dobbin 1941).

C. dentifera Dobbin—Washington (Dobbin 1941).

C. elongata Dobbin—Washington (Dobbin 1941).

C. fuscatus Jurine—Illinois (Sharpe 1897); Ohio, Georgia, Delaware (Turner 1894); Massachusetts (Tressler).

C. hirsutus (Fischer)—Pribloff Islands (Tressler).

C. horridus Sars—Ontario (Sars 1926, Tressler).

C. mollis Furtos—Florida (Furtos 1936).

C. obliqvus Brady—Arizona, D. C., Maryland (Tressler).
C. passaica (Sharpe)—Massachusetts, New Jersey (Sharpe 1918) (?).
C. reticulatus Daday — Illinois (Sharpe 1918, Hoff 1942, 1943a); Virginia, Maryland (Tressler).
C. splendida Furtos — Ohio (Furtos 1933); Massachusetts (Furtos 1935); New York (Tressler).
C. tincta Furtos—Ohio (Furtos 1933); Michigan (Tressler).
C. tuberculatus (Sharpe)—Illinois, Indiana (Sharpe 1918) (?).

Genus *Candocypria*

C. osborni Furtos—Ohio (Furtos 1933).

Genus *Herpetocypris*

H. chevreuxi (Sars)—Utah (Tressler).
H. meridana Furtos—Yucatan (Furtos 1936).
H. reptans Baird—California (Sharpe 1918); Washington (Dobbin 1941).
H. testudinaria Cushman—Newfoundland (Cushman 1908).

Genus *Stenocypria*

H. longicomosa Furtos—Lake Erie, Ohio (Furtos 1933).

Genus *Stenocypris*

S. fontinalis Vavra—Yucatan (Furtos 1936); Trinidad (Tressler).
S. malcolmsoni (Brady)—Yucatan (Furtos 1936); Trinidad (Tressler).

Genus *Ilyodromus*

I. pectinatus Sharpe—South Carolina (Sharpe 1918).

Genus *Cypretta*

C. bilicis Furtos—Florida (Furtos 1936).
C. brevisaepta Furtos—Florida (Furtos 1934, 1936).
C. intonsa Furtos—Florida (Furtos 1936).
C. nigra Furtos—Florida (Furtos 1936).
C. turgida (Sars)—North Carolina (Furtos 1936).

Genus *Cypridopsis*

C. aculeata (Costa)—Ontario (Sars 1926).
C. helvetica Kaufmann — Ottawa (Sars 1926, Tressler); Utah, Oklahoma (Tressler).
C. inaudita Furtos—Yucatan (Furtos 1936).
C. mexicana Furtos—Yucatan (Furtos 1938).
C. niagrensis Furtos—Yucatan (Furtos 1936).
C. okeechobei Furtos—Florida (Furtos 1936).
C. rhomboidea Furtos—Yucatan (Furtos 1936).
C. vidua (O. F. Müller) — Ohio, Lake Erie (Furtos 1933); Illinois (Hoff 1942); Missouri (Ferguson 1944); Tennessee (Hoff 1943b); Mississippi (Hoff 1943d); Ontario (Sars 1926, Tressler); Washington (Dobbin 1941); Florida (Furtos 1936); Newfoundland (Alm 1914); Massachusetts (Cushman 1907); Montana, Utah, D. C., Maryland, Michigan, Louisiana, Texas, South Carolina, Wisconsin, New York, Trinidad (Tressler).
C. viduella Sars—Yucatan (Furtos 1936).
C. yucatanensis Furtos—Yucatan (Furtos 1936).

Genus *Potamocypris*

P. comosa Furtos—Lake Erie (Furtos 1933).

P. elegantula Furtos—Ohio (Furtos 1933).

P. illinoisensis Hoff—Illinois (Hoff 1943c).

P. islagrandensis Hoff—Louisiana (Hoff 1943d).

P. smaragdina (Vavra) — Ohio, Lake Erie, Illinois (Furtos 1933); Illinois (Hoff 1942); Missouri (Ferguson 1944); Mississippi (Hoff 1943d); Tennessee (Hoff 1943b); Illinois (Sharpe 1918); Washington (Dobbin 1941); Mexico (Sharpe 1897); Texas, Louisiana (Tressler).

P. variegata (Brady and Norman)—Ohio (Furtos 1933).

Family DARWINULIDAE

Genus *Darwinula*

D. stevensoni (Brady and Robertson) — Lake Erie, Ohio (Furtos 1933); Georgia (Turner 1895); Illinois (Hoff 1942); Massachusetts (Furtos 1935); Yucatan (Furtos 1936); Michigan (Tressler).

Family CYTHERIDAE

Genus *Metacypris*

M. americana Furtos—Yucatan (Furtos 1936).

M. maracaoensis Tressler—Puerto Rico (Tressler 1941).

Genus *Entocythere*

E. cambaria Marshall—Wisconsin (Marshall 1903, Tressler).

E. claytonhoffi Rioja—Mexico (Rioja 1942).

E. columbia Dobbin—Washington (Dobbin 1941).

E. copiosa Hoff — Illinois (Hoff 1942); Louisiana, Arkansas, Tennessee (Hoff 1943e).

E. dobbinae Rioja—Mexico (Rioja 1944).

E. donaldsonensis Klie—Indiana (Klie 1931).

E. dorsorotunda Hoff—Florida, Georgia (Hoff 1944).

E. eliptica Hoff—Florida, Georgia (Hoff 1944).

E. equicurva Hoff—Georgia, Florida, Alabama (Hoff 1944).

E. heterodonta Rioja—Cuba, Mexico (Rioja 1940).

E. hobbsi Hoff—Georgia, Florida, South Carolina (Hoff 1944).

E. humesi Hoff—New York (Hoff 1943e).

E. illinoisensis Hoff—Illinois, Arkansas (Hoff 1942).

E. insignipes (Sars)—Canada (Sars 1926).

E. mexicana Rioja—Mexico (Rioja 1944).

E. riojai Hoff—Illinois, Arkansas (Hoff 1943e).

E. serrata Hoff—Illinois (Hoff 1944).

E. talulus Hoff—Florida (Hoff 1944).

Genus *Limnicythere*

L. glypta Dobbin—Washington (Dobbin 1941).

L. illinoisensis Sharpe—Illinois (Sharpe 1918).

L. inopinata Baird—Washington (Dobbin 1941).

L. ornata Furtos—Lake Erie (Furtos 1933).

L. reticulata Sharpe—Illinois (Sharpe 1897, Hoff 1942.

L. sancti-patrici Brady and Robertson—Michigan, Texas (Tressler).

L. verrucosa Hoff—Illinois (Hoff 1942).

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Some Observations on the Variation in Wing Venation in the Mycetophilidae (Diptera)

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Wing venation has been greatly used in the separation of Mycetophilidae. Such characters are used in distinguishing these flies, in some cases even to the species.

It has been recognized that some of the veins vary. Thus Edwards (1925) recorded the absence of the vein R_4 in the following genera: *Diomomus, Empalia, Polylepta, Monoclona, Mycomyia, Sciophila* and *Tetragoneura.* The presence of the vein R_4, thus forming a small cell in the radial field, had been the most commonly used character in placing these genera in the subfamily Sciophilinae. Edwards recognized that the vein R_4 was variable in position and presence. Hence he united all of the genera of Sciophilinae of Johannsen together with those members of the Mycetophilinae having the wing microtrichia irregularly arranged as the Sciophilinae of Edwards.

While making some identifications of these insects, certain variations in wing venation, within a single species, were noted. These seem worthy of record since, as previously stated, venation has been commonly used as a means of recognition.

The observations were made on three different species and two genera of gnats. Each will be discussed separately.

Variation of the Subcostal Vein in MYCOMYIA OBLIQUA Say

The examination of a series of *M. obliqua* was initiated by the discovery of a specimen having the subcostal vein ending in R_1. According to Johannsen's key (1910:166), the specimen would run to *Mycomyia littoralis* Say. However, on the basis of genitalic characters, the specimen proved to be *M. obliqua.*

A series of slide mounts of *M. obliqua* was made. All were checked by genitalic characters. A study of the wing venation was made. The various ratios obtained were determined with the aid of an ocular micrometer having a movable scale. In addition to the wing characters commonly used, the relative lengths of the prothoracic basitarsus and tibia were determined.

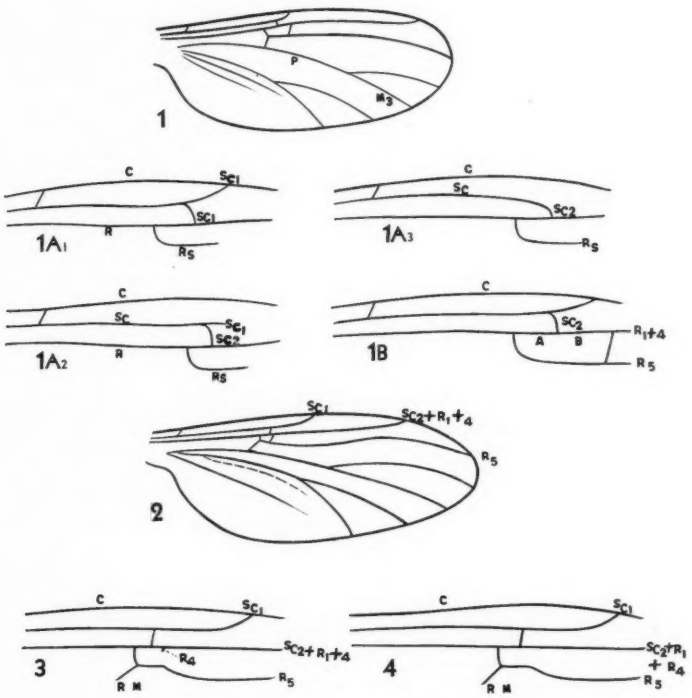
The characters studied included the following: 1) Termination of the subcostal vein. Sc. may end in the costa, free, or in R_1 as indicated in fig. 1 A, (1), (2), (3). Termination of Sc_2 in respect to cell R_1. In this genus the termination of Sc_2 has been used as a specific character. In order to make accurate observations, the distance from the origin of R_S to the termination of Sc_2 (fig. 1B(a)) was determined. The distance from Sc_2 to R_4 (fig. 1B(b)) was also made. A ratio of 6:12 as indicated in table of data would indicate

that Sc_2 entered R_1 at a point 1/3 the distance between the origin of R_S and the point where R_4 enters R_1+2.

Another characteristic commonly employed has been the ratio of the length of the petiole of media to the length of the second branch of media (M_3). In figure 1 this is represented by P and M_3.

Another characteristic is the branching of cubitus in regard to the proximal end of the r-m crossvein.

The final characteristic to be studied was the comparative lengths of the prothoracic tibia and basitarsus:



Figs. 1-4. 1. Wing of *Mycomyia obliqua;* $1A_1$. Wing showing normal ending of subcostal vein; $1A_2$. Wing showing Sc_1 terminating as a stub; $1A_3$. Wing showing absence of Sc_1; 1B. Wing showing relative length of first and second elements of R_1 (A:B) as determined by the ending of Sc_2; 2. Normal wing of *Polylepta obediens;* 3. Section of wing of *P. obediens* showing vestige of vein R_4; 4. Section of wing of *P. obediens* showing absence of vein R_4; 4. Section of wing of *P. obediens* showing absence of vein R_4. Illustrations by Elmer Smith.

The data obtained appeared in tabular form.

Specimen Number	Termination of subcosta	Ratio a - b	Ratio length of petiole of M to 2nd branch of M (M_2)
1	free	6 - 12	68 - 54
2	costa	7 - 13	62 - 56
3	costa	7 - 8	74 - 58
4	costa	7 - 13	76 - 53
5	free	6 - 12	73 - 55
6	radius	6 - 8	65 - 58
7	free	5 - 10	60 - 57
8	radius	9 - 11	70 - 64
9	costa	8 - 12	65 - 64
10	costa	9 - 10	70 - 55
11	costa	8 - 14	70 - 62
12	costa	6 - 7	62 - 53
13	costa	9 - 10	67 - 62
14	costa	4 - 14	72 - 60
15	costa	10 - 10	70 - 62
16	radius	10 - 8	66 - 51
17	costa	11 - 10	64 - 63
18	costa	8 - 13	74 - 51
19	radius	7 - 9	63 - 57
20	costa	8 - 11	68 - 62

It is recognized that more specimens are necessary before attempting to make any correlation of characters. However, it can be stated that considerable variation occurs in the behavior of the subcostal vein. Thus in 65% of the specimens examined, Sc_1 was present ending in the costa and the specimens on wing structure would be identified as *Mycomyia obliqua*. In 20% of the specimens Sc_1 was present but ended free. These would then run to *obtruncata* or *sequax* in Johannsen's key. In 15% of the specimens studied Sc_1 was entirely lacking and Sc_2 ends in R_1. These specimens on the basis of wing structure would be *M. littoralis*. Of course all these specimens can be separated by means of genitalic characters or other characteristics more reliable than the termination of the subcostal vein.

A second variable characteristic is the termination of the vein Sc_2 in relation to the cell R_1. An analysis of the data reveals the following conditions: Five per cent of the specimens had Sc_2 ending at middle of cell R_1; 10% had Sc_2 ending beyond middle of cell R_1, and 85% had Sc_2 ending before middle of cell R_1. Of the last-named group, 35% ended just before middle of cell, 25% had Sc_2 ending 1/3 length of the cell, and the remainder showed a variation of from 1/5 to 2/5 the length of the cell.

The ratio of the length of the petiole of media to the second branch of media (M_3) varied considerably, but with the exception of two specimens the petiole of media was distinctly longer than M_3. In the two exceptions, the petiole and M_3 were subequal. This would indicate that care must be used in making observations if this character is to be employed.

The relation of the length of the prothoracic basitarsus to the tibia was sufficiently constant so that no measurements were recorded. In all instances the tibia was longer.

Variation of R_4 in POLYLEPTA OBEDIENS Johannsen

Another interesting variation was observed in *Polylepta obediens*. During the examination of a series of this species, two specimens were found with abnormal venation. Figure 2 indicates the appearance of the wing of a normal individual. Figure 3 represents the condition in which only a small stub of R_4 terminating in Sc_2+R_1, remains. Figure 4 shows another condition noted in which R_4 was completely lacking. On the basis of venation this specimen would run to the subfamily Mycetophilinae in Johannsens key and the insect might have been considered to be a species of Leptomorphus. All specimens had genitalia typical of *Polylepta obediens*.

Variation in MYCOMYIA IMITANS Johannsen

A third interesting variation has been already reported by the writer (1940, Can. Ent. 72:49, fig. 8). A specimen of *Mycomyia imitans* Joh. was observed in which an added element appeared in the subcoastal field. This would doubtless be considered a supernumerary crossvein.

CONCLUSIONS

It is obvious from the study of *Mycomyia obliqua* Say that sufficient variation occurs in the behavior of the subcostal vein to make its use questionable as a determining specific character.

It is likewise obvious that in the case of *Polylepta obediens* Joh. the behavior of vein R_4 is not constant.

It is suggested in view of the facts presented that considerable care must be observed in the use of slight variations in the subcostal and radial fields as the basis of specific determinations, at least in the subfamily Sciophilinae.

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A Morphological Study of the Male and Female Genitalia of Heliothis armigera (Corn Earworm Moth)

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The consistency of genital characters in insects is universally recognized. This consistency is applied in species differentation. As in any other taxonomic study, identification of species by means of genitalia depends upon a valid recognition of morphoogical characters.

Comparatively little detailed morphological work has been done on the genitalia of specific insects. The purpose of this study is to identify the structural characters of a generalized type of genitalia (represented by *Heliothis armigera)* by the use of terms which have more or less been accepted as standard.

Specimens selected.—Much of this work was done while the author was on tour of duty with the armed services in Hawaii. Specimens obtained locally, as well as forms sent from California and Wisconsin, were used in making the study. Numbers and sources of specimens were as follows:

Source	Male	Female
Hawaii		
Museum specimens	5	5
University Collection	8	8
Field Collections	9	11
University of California	5	3
University of Wisconsin	4	5
Total	31	32

Laboratory procedure.—The method outlined by August Busck (1942) was generally followed. Inasmuch as a correct interpretation of the morphology of genitalia depends to some extent upon technique in preparation, details of the procedure adopted are given.*

1. The abdomen was first detached, by holding the specimen rigid, perforating the junction between abdomen and thorax with a needle, and firmly pressing upward on the abdomen. It was found expedient to use the entire abdomen, because some of the genital structures extend anteriorly almost as far as the thorax, particularly in the female.

2. KOH (caustic potash) was used to clear the abdomen of all non-sclerotized structures. Abdomens were allowed to soak in a 10% solution for from 1-3 days, or in a 5% solution for one week. For immediate examination, boiling the abdomens for a few minutes in a 10% solution was satis-

* This method is applicable only to the study of sclerotized structures which are not destroyed by KOH treatment. Non-sclerotized structures should be studied by microdissection.

factory. The absorption of KOH was hastened by preliminary immersion in 70% alcohol.

Bouin's fixative and 10% formalin are good preservatives for freshly collected specimens. These fixatives must be washed out in water before the KOH treatment.

3. The abdomen was washed in water to remove the KOH, and the contents pressed out with a camel's hair brush. The specimen was then transferred to a watch glass and the genitalia removed under water, using dissecting needles and a low-power microscope.

4. The specimens were stained by immersion in .5% mercurochrome solution for 2 minutes. This stain is easily prepared, does not wash out readily in alcohol, and stains deepest those areas of heaviest sclerotization.

5. It was necessary to "spread" the male genitalia. The harpes were spread with needles, and micro-pins inserted through the harpes into cork or paraffin. These were left in a spread position for 15-30 minutes.

6. Specimens were dehydrated in 70% alcohol for 15 minutes,* then placed in 95% alcohol for 20 minutes. Preliminary immersion in the weaker alcohol is not considered essential by some workers (Busck, 1942).

7. The genitalia were cleared in clove oil for 10 minutes. Specimens may be left immersed in this clearing agent for an hour or more, although they tend to become brittle with prolonged treatment.

8. The specimens were placed in xylol to remove the oil and for further clearing. A few minutes time was sufficient for this process, although with some female specimens, manipulation was necessary in washing the bursae in order to obtain a clear mount.

9. Raised mounts were necessary because of the thickness of the genitalia, and "props" made from pieces of broken cover glass were used to provide support for the cover slip. A thin solution of gum damar mounting medium was used. The specimen was placed on the slide, arranged in the desired position, and covered liberally with damar. A cover glass was first wet on the under-surface with xylol to prevent bubbles in the mount, and then lowered over the specimen.

Ventral, lateral, and dorsal mounts were made. It was found unwise to rely entirely upon fixed mounts for study. Much of the examination was made on unmounted specimens, with the aid of a low-power binocular and dissecting needles.

10. The slides were dried in a flat position, and subsequently labeled, with details as to the source of the specimens, etc.

Drawings.— The drawings were made from mounted genitalia with a camera lucida. They are referred to within the text.

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* The processes of spreading, staining and initial dehydration may be combined by submerging the pinned specimen in a solution of 70% alcohol, to which a few drops of mercurochrome stain have been added.

Terminology.—The literature concerning the nomenclature of the male genital structures is very confusing. Much has been written in regard to terminology, and attempts have been made to clarify definitions of these structures. It still remains difficult, however, to apply these definitions to one particular species. However, Beirne, (1942) in his excellent work on this subject, considers a composite type within the Lepidoptera, and defines a large number of male genital structures. It is interesting to note that he follows largely the terminology laid down by Pierce (1909).

A discussion of terminology as applicable to the species studied would constitute a paper in itself. However, since confusion still exists, particularly in the terminology concerning the male genitalia, all of the terms used in describing both the male and female genitalia of *H. armigera* are defined. General usage at the present time, rather than priority, was the criterion used in selecting the following definitions from the sources noted. In some instances the definitions were paraphrased for the sake of conciseness and clarity.

AEDEAGUS (♂) A more or less strongly sclerotized tube, which contains and protects the delicate membranous penis (Busck, 1942).

ANAL TUBE (♂) This structure is not strictly defined by workers, but is understood to mean the posterior portion of the intestinal tract. It may be more or less sclerotized.

ANELLUS (♂) A cone-like tube through which the aedeagus enters the ninth somite (Eyer, 1924).

ANTERIOR APOPHYSIS (plural, apophyses) (♀) A prolongation of the eighth abdominal segment in the form of a slender segmental rod which serves for muscle attachment (Busck, 1932).

BURSA COPULATRIX (♀) A pouch into which the sperms are discharged before entering the spermatheca (Wigglesworth, 1939).

BURSA SEMINALIS* (♀) A heavily sclerotized, spirally coiled pouch in *H. armigera* which is a diverticulum of the ductus bursae and receives the tube-like portion of the spermatophores.

COLLETERIAL GLANDS (♀) Accessory glands of the female secreting an adhesive substance used to fasten the eggs to a support (Snodgrass, 1935).

CORONA (♂) Uniform rows of incurved spines attached to the distal and ventral edges of the harpes (Pierce, 1909).

CORNUTI (♂) Sclerotized plates or spines, which may be permanently attached to the penis or may be deciduous and remain in the bursa of the female after copulation (Busck, 1942).

DUCTUS BURSAE (♀) The duct in female Lepidoptera extending from the ostium to the bursa copulatrix (de la Torre Bueno, 1937).

DUCTUS SEMINALIS (♀) In female Lepidoptera, the tube or canal connecting the bursa copulatrix with the common oviduct or oviductus communis (de la Torre Bueno, 1937).

GENITAL PLATE (♀) Not strictly defined, but refers to the portion of the eighth abdominal sternite surrounding the ostium bursae.

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*The term "bursa seminalis" is suggested by the author. Pierce (1942) refers to an "elongate spinal pouch" in describing this structure.

HARPES (♂) Paired clasping organs which articulates to the posterior-margins of the vinculum (Eyer, 1924). These structures are termed *valvae* or *claspers* by some workers.

JUXTA (♂) A triangular or quadrate plate articulated to the ventral surface of the anellus (Eyer, 1924). Strictly, the juxta is not a structure distinct from the anellus in *H. armigera*, but may be considered as forming a part of that complex organ.

LATERAL LOBES (♂) Expansions from the lateral edges of the tegumen or of the *pedunculi* (Beirne, 1942).

OSTIUM BURSAE (♀) The opening of the bursa copulatrix in Lepidoptera, equivalent to the vulva of female insects having the genital opening on the eighth segment (Snodgrass, 1935).

OVIDUCT (♀) One of the paired tubes through which the egg passes from the ovarian tubes into the vagina (de la Torre Bueno, 1937).

OVIDUCTUS COMMUNIS (♀) The median outlet of the female genital system in insects, usually opening into a genital chamber, or vagina (de la Torre Bueno, 1937).

OVIPOSITOR (♀) In forms with two genital openings, normally consists of two soft, flattened, hairy lobes, surrounding the anal opening and the outlet for the oviduct (Busck, 1932).

PEDUNCULI (singular, pedunculus) (♂) Extensions of the lower lateral corners of the tegumen which meet the upper basal corners of the harpes (Beirne, 1942).

PENIS (♂) (see aedeagus).

POSTERIOR APOPHYSES (♀) Anterior prolongations of the ninth segment in the form of two long, slightly curved, chitinous rods which serve for the attachment of muscles which move the ovipositors (Busck, 1932).

SACCULUS (♂) In the genitalia of male Lepidoptera, the ventral part of the harpe (de la Torre Bueno, 1937).

SACCUS (♂) In the genitalia of male Lepidoptera, a midventral cephalad projection of the vinculum inside the body; serves as a muscle attachment when present (de la Torre Bueno, 1937).

SEGMENT VIII (♀) The eighth abdominal segment.

SIGNA (Singular, signum) (♀) One or more heavily chitinized and often elaborate structures in the wall of the bursa copulatrix of female Lepidoptera (de la Torre Bueno), 1937.

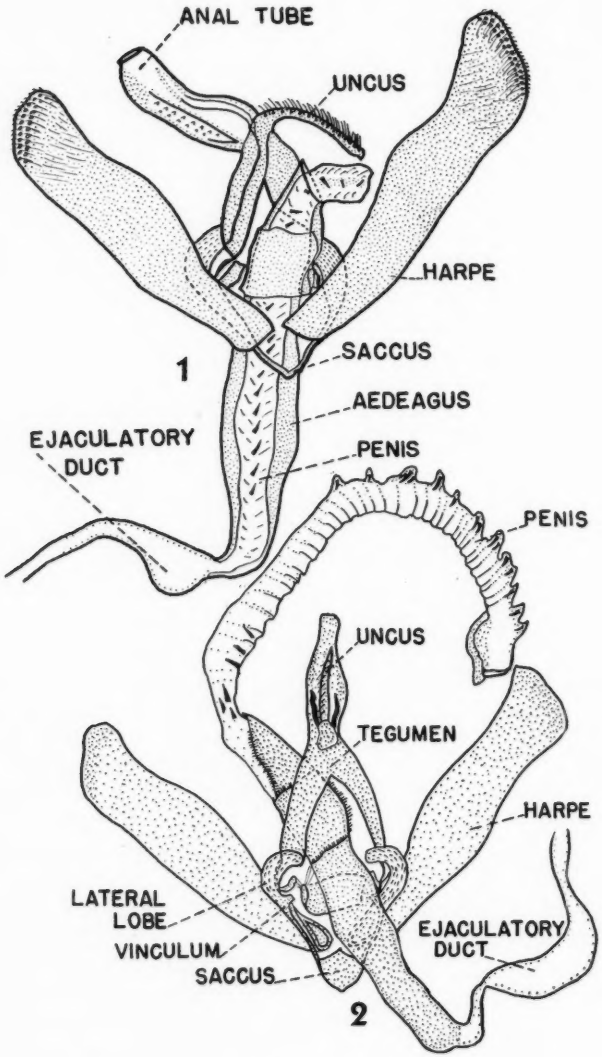
SPERMATHECA (♀) A pouch lined with cuticle in which the spermatozoa received at copulation are stored (Wigglesworth, 1939).

SPERMATOPHORE (♂, ♀) A covering or capsule about the spermatozoa (de la Torre Bueno, 1937).

SUBSCAPHIUM (♂) Ventral sclerotization of the anal tube, which articulates with its basal or anterior end with the inside of the gnathos, when present (Beirne, 1942).

TEGUMEN (♂) The tergal portion of the ninth somite which forms the dorsal part of the genitalia (Eyer, 1924).

UNCAS (♂) Typically in the form of a large, strongly sclerotized, tapering arm arising from a broader base, the anterior edge of which is attached to the caudal margin of the tegumen (Beirne, 1942).



Figs. 1, 2. Male Genitalia of *Heliothis armigera*. 1. Ventral view. Aedeagus shown as if in longitudinal section; 2. Dorsal view. Penis withdrawn and separated away from the lip of the aedeagus.

VAGINA (♀) The tubular structure formed by the union of the oviducts in the female, opening externally to admit the passage of the egg to the ovipositor (de la Torre Bueno, 1937).

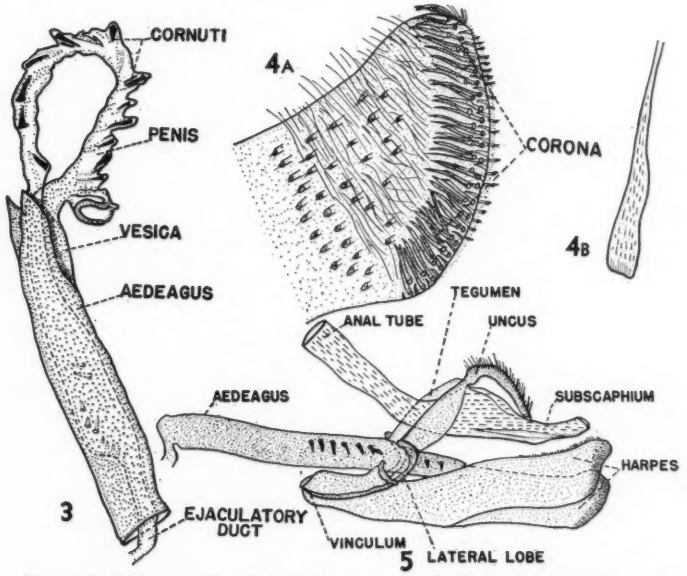
VESICA (♂) A terminal membranous part of the aedeagus (Snodgrass, 1935).

VINCULUM (♂) A U-shaped sclerite derived from the ninth abdominal sternite, its arms articulating dorsally with the tegumen and the harpes with its caudal margin (de la Torre Bueno, 1937).

THE MALE GENITALIA

The *anal tube* passes between the arms of the tegumen. It is sclerotized laterally and ventrally. Situated ventrally and medially on the anal tube is a region of roughened area, consisting of numerous, very small tooth-like structures, not unlike the surface of the anellus and the outer surface of the penis. This region of roughened area may be considered as the *subscaphium*. The subscaphium in this species bears a descriptive resemblance to the *pentagon* of Gosses (1882) (Fig. 5).

The two arms of the tegumen meet in the dorsal midline to form an arch through which the anal tube and the aedeagus pass. Attached to the caudal margin of the tegumen is the *uncus*, a large hairy tapering arm, heavily sclerotized, and hooked at its apex (Figs. 1, 7).



Figs. 3-5. Male genitalia of *Heliothis armigera*. 3. Aedeagus and everted penis; 4a. Distal part of harpe (ventral view); 4b. Scale from harpe; 5. Genitalia (lateral view).

Anteriorly, the tegumen is expanded, and bears hair tufts near its medial edges. It is strongly attached to the *vinculum* by a curved, heavily sclerotized rod termed the *pedunculus (Pleurite* of Forbes) (Fig. 7).

The vinculum forms the framework to which the principal parts of the male genitalia are attached. In this species, it is in the form of a V, and terminates anteriorly in a sclerotized pocket. This pocket is called the *saccus.* To the vinculum are attached the *lateral lobes;* they curve laterally and caudally, and are weakly attached to the lateral caudal edges of the tegumen and to the pedunculi. The vinculum lies exterior to the attachment of the harpes, and some authorities contend that it represents the sclerotization of the membrane between the 8th and 9th segments (Fig. 5, 6).

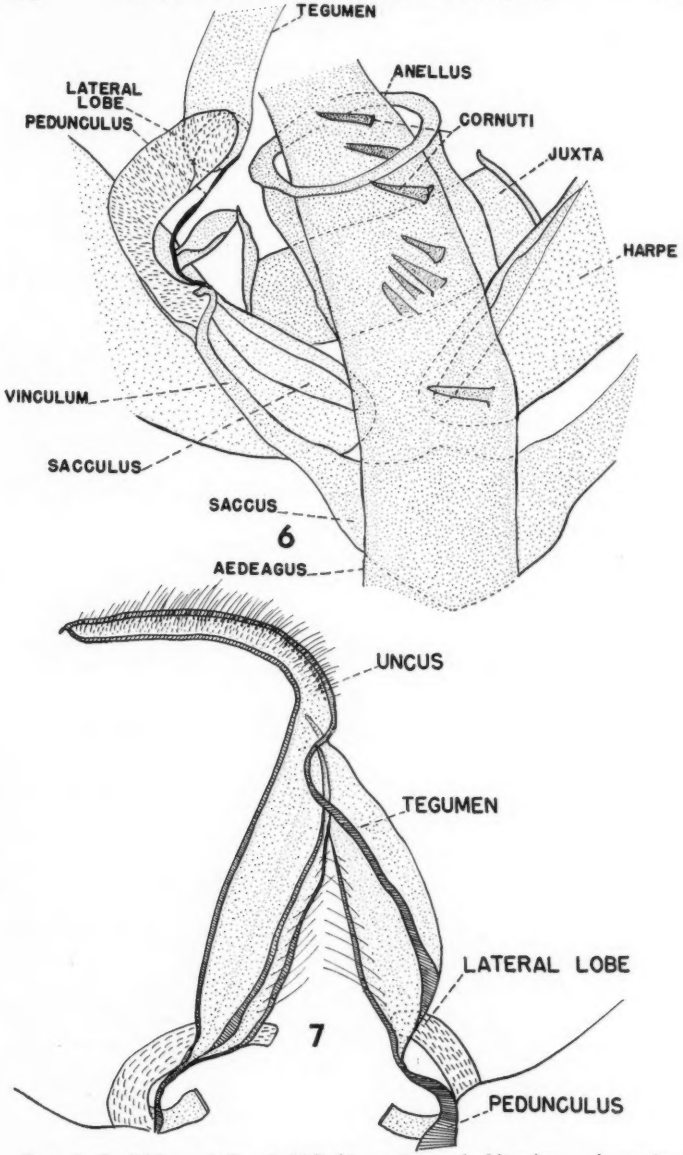
The *juxta* is a curved plate lying roughly in the center of the armature between the harpes. It is weakly attached to the saccus, but is articulated ventrally to the *anellus. The* juxta forms a trough, open dorsally, through which the aedeagus might slide in its position dorsal to the saccus and ventral to the arch formed by the arms of the tegumen(Fig. 6).

The *anellus* is a sclerotized membrane completely surrounding the aedeagus, except for a small ventral portion. Stretched by extension of the aedeagus, the length of the anellus may approximate half the length of the tegumen. It bears very small, short spines on its margins.

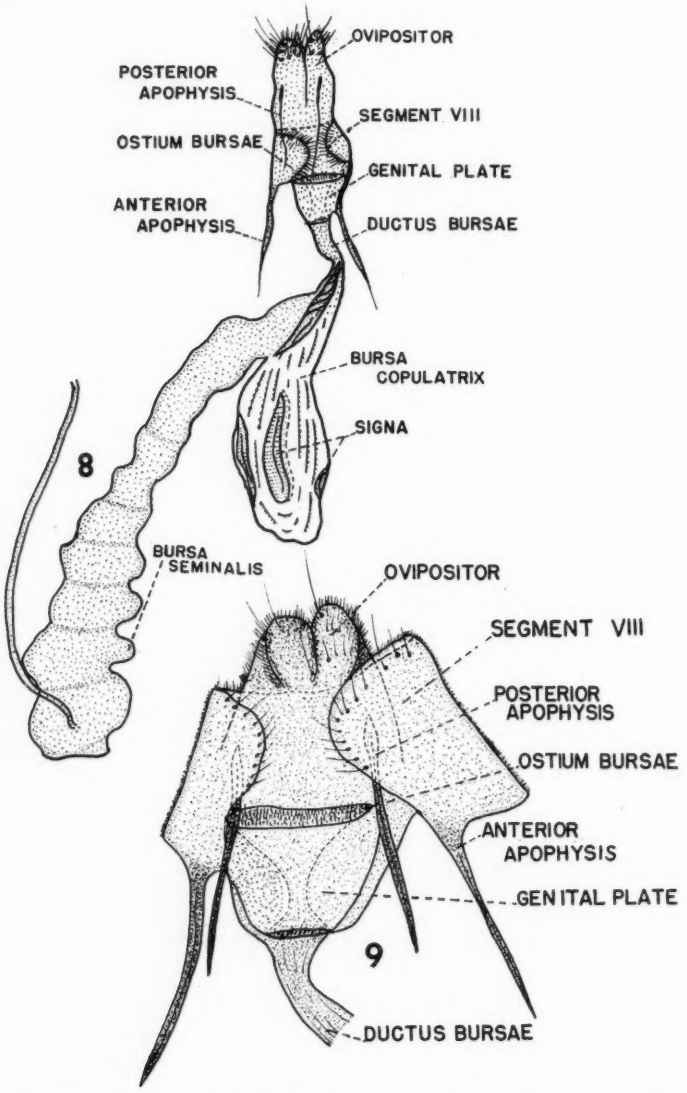
The position of the *aedeagus* has already been described. It is a long cylindrical shaft of heavily sclerotized tissue, and is attached to the anellus. Telescoped within the aedeagus are folds of a lightly-sclerotized membrane called the penis, which may be everted posteriorly to a length equal to or exceeding the length of the aedeagus proper (Figs. 2, 3). It is attached by the membranous *vesica* to the lip of the aedeagus. The outer surface of the penis bears short toothed spines and longer, thorn-like processes within the folds of the membrane. These processes are called *cornuti.* In some species the cornuti are deciduous, that is, remain in the bursa copulatrix of the female after copulation. Since none were found in the bursae of females examined, it is probable that in this species the cornuti remain permanently attached to the wall of the penis. The caudal portion of the *ejaculatory duct* is also lightly sclerotized, and enters the aedeagus anteriorly to join the membranous penis.

The *harpes* are relatively simple and generalized. They bear several different types of scales, hairs and spines: (1) short cylindrical spines covering the entire surface, and appearing toothed under high magnification, (2) long tapering scales attached by their narrow ends to the margins (Fig. 4B), (3) long curved spines similar to those found on other parts of the armature, and thickest on the anterior margins, (4) fine hair on the ventral surface, and (5) approximately three rows of large incurved spines attached to the distal margins of the ventral surface—these constitute the *corona* (Fig. 4A). Pierce (1909) makes reference to the scales and the corona in his brief description of this species. The harpes are bordered with abundant growth of hair, and it is necessary to remove most of the hair in order to make a clear mount.

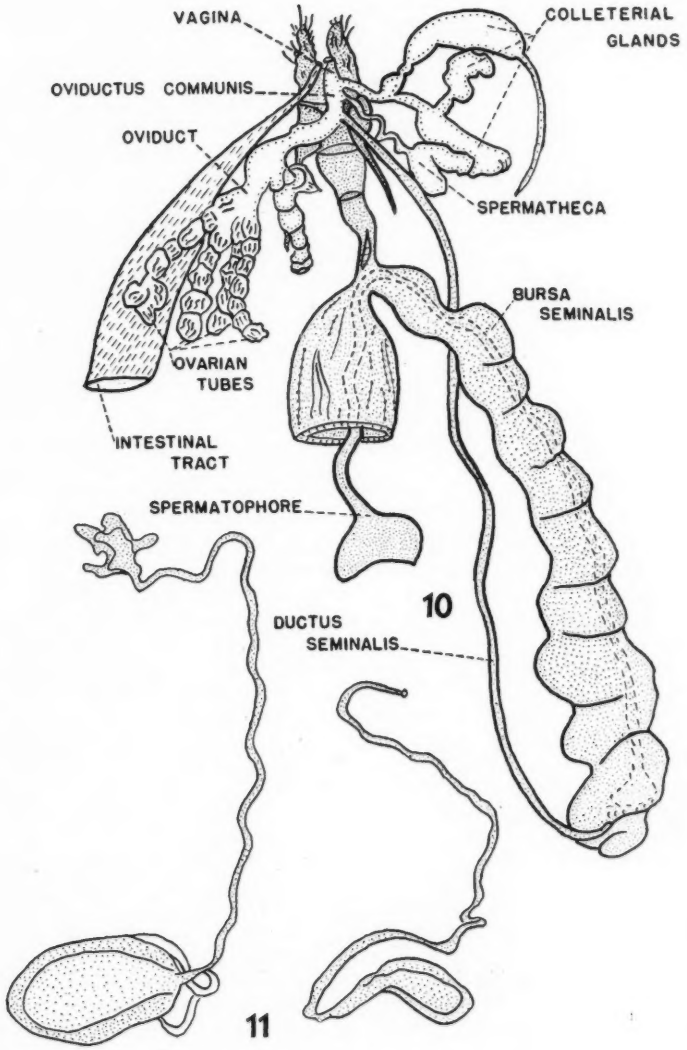
The harpes do not articulate with each other, but may be weakly attached



Figs. 6, 7. Male genitalia of *Heliothis armigera*. 6. Vinculum and associated structures (dorsal view); 7. Tegumen, uncus, and associated structures (ventral view).



Figs. 8, 9. Female genitalia of *Heliothis armigera*. 8. Ventral view; 9. Posterior portion (ventral view).



Figs. 10, 11. *Heliothis armigera*. 10. Genitalia of fertilized female; 11. Spermatophores.

to the saccus. The ventral portion of the harpes is called the *sacculus*. Toward their caudal margins, the harpes are articulateed to the prongs of the vinculum on its ventral surface (Fig. 6).

THE FEMALE GENITALIA

For convenience of description, the female genitalia may be considered under three heads: (1) sclerotized structures which resist KOH (2) non-sclerotized structures which are destroyed by KOH, and (3) structures introduced in the copulatory process.

Sclerotized structures.—The *ovipositor* consists of two curved, hairy lobes which form a tube, opening caudally, and within which the vagina and anal tube open. Normally the ovipostor is found partly or entirely telescoped within the eighth segment, to which it is attached. Segment VIII fits like a saddle around the ovipositor, and is open ventrally (Fig. 9).

The lobes of the ovipositor bear medially a pair of long rods which serve as attachments for the muscles used in oviposition. These rods are called the *posterior apophyses*.

The eighth segment is referred to above. It bears the *genital plate*, which is composed of folds of heavily sclerotized tissue surrounding the copulatory opening. This opening is called the *ostium bursae*. Its surface is covered with short hairs, probably sensory in function. The eighth segment also bears the *anterior apophyses* at its lateral anterior margins.

The ostium bursae is the ventral opening of the *ductus bursae*, a tube which continues anteriorly and gives off two diverticula, the *bursa copulatrix* and the *bursa seminalis* (Fig. 8).

The *bursa copulatrix* is a lightly sclerotized, transparent sac which receives the penis of the male during copulation. Its surface is covered with toothed prominences. In its inflated condition, four heavily sclerotized areas are readily visible on its surface. These areas are called *signa*. There are three long signa and one short signum in this species, structurally apposed (Fig. 8).

The *bursa seminalis* arises from the ductus bursae at approximately the same point as the bursa copulatrix. It is spirally coiled, heavily sclerotized, and often extends anteriorly for almost the entire length of the abdomen. Near its anterior tip is attached the *ductus seminalis*, a duct which unites posteriorly with the oviductus communis (Fig. 10).

Non-sclerotized structures.—The *vagina* is the posterior continuation of the oviductus communis. The lobes of the ovipositor surround both the vaginal opening and the posterior opening of the intestinal tract. The anterior continuation of the *oviductus communis* is the *oviduct*, which in turn leads to the paired *ovaries*, each of which consists of four *ovarian tubes*. (Fig. 10). Eggs, developing within the ovarian tubes, reach the outside of the abdomen through the vagina, after being fertilized in the oviductus communis.

Besides receiving the ductus seminalis, the oviductus communis receives ducts from the *colleterial glands* and from the *spermatheca*. The colleterial glands are of horny cuticular structure. They and their attached ducts are wrapped and entangled with other parts of the genitalia. It is evident, however,

that the oviductus communis serves as an outlet for these glands. Their function is probably to supply the "cementing material" which attaches the eggs to the object upon which they are oviposited.

The spermatheca is a relatively inconspicuous structure. Its function is no doubt an important one—to store the sperms until the time when fertilization takes place. In the specimens examined, the sperms were crowded into a tight packet within the spermatheca, and exceedingly numerous.

Structures introduced in the copulatory process.—The *spermatophores* of *H. armigera* are introduced in copulation through the ductus bursae and are deposited within the bursa copulatrix. They are insoluble in KOH, hollow, and capsulated at the end which is contained within the bursa copulatrix (Figs. 10, 11). It is within this swollen, globular, chitinous sac that the sperms are contained. As many as three spermatophores were recovered from one female. Busck (1932) states that each spermatophore indicates a separate mating.

The sperms are spirilla-like organisms which average well over 100 microns in length. They stain quite readily with gentian violet.

The morphological study would indicate that the sperms make their way through the tube-like portion of the spermatophore (enclosed within the bursa seminalis) to the ductus seminalis. From the ductus seminalis they enter the oviductus communis. If fertilization does not occur at that time, it is probable that the spermatozoa are stored in the spermatheca until the time when fertilization does occur.

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Limblessness and Correlated Changes in the Girdles of a Comparative Morphological Series of Lizards*

Paul Scott Stokely

Introduction

Although valuable contributions to the osteology of the Sauria had been made previous to the opening of this century by a number of investigators (Cuvier, 1825; Dumeril and Bibron, 1835; Gegenbaur, 1864, 1865; Fürbringer, 1870, 1900; Sabatier, 1880; Cope, 1892a, 1892b; Siebenrock, 1895), it was still necessary for Noble (1921) to say, "Altogether too little is known about the osteology of the Lacertilia to be entirely certain about the direction in which evolution has progressed." The value to the paleontologist of more precise information concerning the osteology of modern lizard forms is patent.

Among contemporary species of lizard with reduced limbs and eyes, regressive evolution is still going on at a rather rapid pace. Attention has been focused on such evolutionary processes by setting up morphological series of forms showing gradual reduction of limbs and girdles. Such series were studied by Essex (1927) and Sewertzoff (1931) and the latter made a pertinent statement concerning such an approach when he said, "It is understood that this series represents a comparative-anatomical series—each species representing the end-point of its independent evolution, or its independent phylogenetic series. But all of these forms have evolved in the same direction so that they give us the general trend of the phylogenetic development, much as in the same way as the limbs of the tapir, rhinoceros, and horse give us the path of the phylogenetic development of the foot of the ancestors of the Equidae".**

In order then to test the theories and findings of previous workers (see History of the Problem) as well as to bring, wherever possible, new light and information on the osteology and evolution of the limbless or nearly limbless Sauria, this present study was undertaken.

Acknowledgment

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** Translation from the German by the author.

specimens. Mr. Schmidt also read the manuscript. Finally; to his colleagues, students and typist who have assisted him in many ways, too numerous to mention, the writer must also acknowledge a debt of gratitude.

History of the Problem

The existence of limbless lizards has posed an interesting and stimulating problem to investigators for many years. It is generally recognized that these snake-like creatures share with the typical four-footed lizards a common plan of bodily structure permitting bones and muscles to be considered homologous. Fürbringer (1870) noted that the differences among this reptile group, when a lizard with completely developed girdles and limbs is chosen as a starting point, depend upon the reduction of homologous parts, that is upon a diminution of their size and efficiency.

Cope (1892b) came to practically the same conclusions as Fürbringer as to how this reduction proceeded during the course of evolution of the Sauria. Both agreed that the reduction of the limbs begins at the digits and progresses proximad. Siebenrock (1895) offered additional evidence in support of their generalization. The investigations by Krieg (1919) convinced him that the reduction of the limbs and girdles and the reduction of the sternal apparatus were two distinct processes. He further contended that great variability and marked asymmetry are two symptoms of reduction. The work of Larsell (1926) brought to light the fact that in lizards the change from a walking to a crawling method of locomotion was accompanied by morphologic changes in the cerebellum.

Regarding the evolution of the limbless lizards, Camp (1923) pointed out that this mode of retrogression occurs only in the autarchoglossids where the presence of a complex body musculature, and more especially of the rectus superficialis, permits more extensive body and tail motion. Within the autarchoglossids he recognized two different types of habitus in correlation with grass-dwelling forms on the one hand and with burrowing types on the other.

Sewertzoff (1931) made observations upon a morphological series of lizards which he had arranged in the order of increase of the number of presacral vertebrae. He found that as the length of the trunk increased, the relative length of the limbs decreased. In the course of their phylogeny the snake-like lizards have not only increased the number of body segments (myotomes, spinal nerves, vertebrae, etc.) but there has also occurred an entire series of related segmental transformations of the skeleton, vertebrae, spinal nerves, and muscles. As body length increased, all ribs (lumbar and cervical) took on the shape characteristic of thoracic ribs. Embryological observations showed Sewertzoff (1931) that the sacral ribs were not displaced in those forms with an increasing number of trunk segments, but developed from somites which lay farther caudad than was the case with the ancestral forms.* Sewertzoff believes with Camp (1923), Essex (1927), and many others that the preliminary condition for reduction is this: an organ which was important in an-

* For more detailed information regarding positional variation of girdles, limbs, etc., see Lebedinsky (1926), Kühne (1931, 1936), Mettig (1939), Schultz and Straus (1945).

cestral forms becomes unnecessary to its possessor through a change in the living conditions in which the descendents live. The biological or specific functional importance of the organ is lost and it may be replaced by another organ with the same general function or another function; the replaced organ being reduced in the descendents.

Of the two types of redutcion distinguished by Sewertzoff it is with the one termed "rudimentation" that we are here concerned. In rudimentation two processes are discernible. In the first an organ becomes progressively smaller than it was in ancestral forms. This results from the fact that in successive generations the first embryonal anlage of the organ in question becomes ever smaller and smaller. This diminution persists throughout the entire ontogeny of the individual so that the adults tend to have the organ reduced. In the second process operating in rudimentation there is a subtraction of the end-stages of ontogeny; a certain part of the developing rudimentary organ is no longer laid down and consequently that part fails to appear in the descendents. The sequence of the phylogenetic subtraction of organ parts corresponds inversely to the sequence of the formation of parts in normal, unreduced organs.

It can be seen from this summary of Sewertzoff's views that he does not hold with Camp and Essex that reduction is the result of arrested embryonic development. He specifically states that the vestigial organ is laid down at the same time as is the homologous organ in normal individuals and that in most cases there is no evidence that the anlage of the organ undergoing reduction suffers a retardation.

Materials and Methods

The material underlying the present account consists of the genera and species listed below. Under each name is given the museum* designation and whatever information is furnished concerning the locality from which the specimen was taken.

Ablepharus boutonii africanus Sternfeld.
M.C.Z. ..... Lumbo, Mozambique.

Acontias percivali Loveridge.
M.C.Z. 40200 Mt. Mbololo, Traita Mts., Kenya, Colony.

Anguis fragilis Linné.
U.N.D. ..... Bonn, Germany.

Anniella pulchra nigra Fischer.
M.C.Z. 7323 Pacific Grove, California.

Brachymeles gracilis Fischer.
M.C.Z. ..... Tatayan to Saub Cotobato Coast, Philippine Islands.

Brachymeles schadenbergii Fischer.
M.C.Z. ..... Tatayan to Saub Cotobato Coast, Philippine Islands.

Chalcides o. ocellatus Forskal.
C.N.H.M. 18225 Arabia; Aden.

Chalcides sepsoides Gray.
C.N.H.M. 618 Gizeh.

* The institutions furnishing material are designated as follows: M.C.Z., Museum of Comparative Zoology (Cambridge, Mass.); C.N.H.M., Chicago Natural History Museum; U.N.D., The University of Notre Dame.

Chalcides striatus Cuvier.
U.N.D. ..... Salamanca, Spain.
Chalcides tridactylus Laurenti.
M.C.Z. 1272 Algeria.
Eumeces anthracinus Baird.
U.N.D. ..... 4 mi. so. of Imboden, Lawrence Co., Arkansas.
Eumeces s. skiltonianus Baird and Girard.
U.N.D. ..... San Diego, California.
Lacerta erhardi riveti Naud.
U.N.D. ..... Nikolic, Macedonia.
Lacerta pityusensis grossae Müller.
U.N.D. ..... Grossa Island, east of Ibiza.
Lacerta sicula campestris Betta.
U.N.D. ..... Unie Island near Lussin, Dalmatia.
Ophiodes striatus Spix.
C.N.H.M. 9026 Brazil: Therezopolis, Fazenda Posse.

The specimens were cleared and the bones and calcified cartilages stained with alizarin sulfonate of sodium according to modifications of the Schultze method described by Davis and Gore (1936). It is presumed that each specimen was that of an adult animal and there is no evidence to the contrary.

To secure the data appearing in Tables 1 and 2, it was necessary to measure the parts indicated in the table-headings. Measurements were taken by means of a pair of dividers and the distances so obtained were converted into figures by comparisons with a standard metric rule. The greatest length of each part for which an index is given, was taken as "the length". The distance from the most antero-ventral to the most postero-lateral point of ossification was taken as the length of the precoracoid. Although the measurements were carefully made and repeated I do not doubt but that quite a margin of error must be allowed for. Some of the species are so small that their tiny structures are impossible to measure with great accuracy by the methods employed. Occasionally a specimen was not so well cleared as were most of them and this made accurate measuring difficult. And sometimes an element would be poorly calcified or ossified (as the case may be) and the exact limits of such a structure could hardly be ascertained. But for the purposes at hand it appears that sufficient accuracy was obtained; that is sufficient exactness for the detection of over-all tendencies and general trends. For the description of the girdles observations were made under a low-power binocular microscope. All drawings were made by the author with the aid of a camera-lucida.

The Pectoral Girdle

THE CLAVICLES

The clavicles are paired bones which in the Scincidae are transversely placed. Camp (1923) contends that broadly expanded, non-perforate clavicles are ancestral among modern forms and that the simple, rounded clavicles have been derived from these. The clavicles of the species forming the morphological series in this present study are depicted in Figs. 1-9. The Anguimorpha are omitted from these figures because their clavicles are peculiarly placed more in an antero-posterior direction than in a transverse position. However, some of the Scincidae in Figs. 1-9 *(Ablepharus boutonii, Brachymeles gracilis,* and

Chalcides sepsoides) possess clavicles which lie at an angle to a transverse line. If these bones lost the plate-like expansion along the posterior border, the results would be not unlike the clavicles of *Ophiodes striatus* and *Anguis fragilis* (Figs. 22, 30). This would follow aong the lines of evolution suggested above by Camp.

The clavicles in this series (Figs. 1-9 and Table 2) which are from the Scincidae are characterized by the marked variation and asymmetry which Krieg (1919) held as symptomatic of reduction. (Wherever the two clavicles are asymmetrical they are both portrayed in Figs. 1-9). It will be noticed that in every case the clavicle has a median expansion and as we go down the series this expansion seems to spread toward the lateral extremity. The lateral extremity is always narrow and connects to the suprascapula close to the scapula. The clavicles are all perforate except those of *Chalcides sepsoides*. These openings seem to be comparatively smaller as we go down the series but become more irregular and more numerous. The posterior margin of the bone is irregularly notched and broken to an increased degree toward the bottom of the series. A glance at Fig. 12 will show that the clavicle of *Lacerta erhardi* more closely resembles that of *Eumeces anthracinus* having a corresponding number of presacral vertebrae.

The expanded posterior portion of the clavicle is much thinner and more delicate than the anterior margin; this is particularly apparent in Fig. 7 *(Chalcides ocellatus)*. It is believed that the indices for the clavicles given in Table 2 are indicative of a peculiar phenomenon. The index for the first, *Eumeces anthracinus,* as well as for the three species of *Lacerta* is low and the indices approximate one another quite closely. From the second species, *Ablepharus boutonii,* downward through the middle of the series the index is considerably higher and then steadily falls. In the tenth form in the series, *Acontias percivali,* the clavicles are completely absent. Does this not suggest that the primitive condition may have been similar to that figured by Camp (1945) for *Prolacerta** and that this was followed by increased expansion and perforation in the beginning stages of habitus transformation, to be succeeded by reduction and eventual disappearance? It is the opinion of Noble (1921) that the clavicles evolved from narrow rods to flat sheets which later became perforate. Camp (1923) suggests that the reduction of the clavicle is associated with the increased development of the M. clavodeltoideus.

THE INTERCLAICLE

The interclavicle together with the clavicles which constitute the secondary shoulder girdle are bones of dermal origin (Gegenbaur, 1865; Bogoljubsky, 1914). The third element of the secondary shoulder girdle, the cleithrum, of Amphibia and early reptiles is lost in the Saurians (Romer, 1945). From embryological and paleontological evidence Camp (1923) believes that the primitive interclavicle of lizards was a rhomboid bone with a long posterior

* In the lower Triassic protosaurian genus *Prolacerta,* the clavicle is a curved boomerang-shaped bone, pointed at each end and with a slight expansion in the middle according to Camp (1945). Fig. 10. Amer. Jour. Sci. **243**:84-101. "*Prolacerta* and the protosaurian reptiles."

process and that the structure is being variously reduced among modern forms. Such a reduction is caused by the action of the deltoid and pectoralis muscles which hollow out the four sides of the rhombus resulting in the cruciform shape seen in the Scincidae (Figs. 14, 15, 20). Here the four limbs of the cross are of equal length and are for the most part slender though widened toward their point of confluence. The anterior median arm separates the clavicles at the midline and most frequently contacts them there. The posterior limb laps the sternum on the ventral side for a short distance; its extremity is frequently cartilaginous. Since the structure is a dermal bone, cartilage can hardly represent an arrested embryonic state but must be a neomorph indicative of reduction as suggested by Fürbringer (1870). The four limbs of the interclavicle of *Chalcides sepsoides* (Fig. 17) are rather stout and the median limb of *Brachymeles gracilis* (Fig. 14) has a somewhat broadened head. The cruciform interclavicle of *Lacerta erhardi* (Fig. 12) is quite similar to that of the Scincidae except that the median anterior limb is considerably shortened. According to Camp (1923) the transverse arms are retained as attachments for the heavy sternohyoid and sternothyroid muscles.

The interclavicle is missing in *Acontias percivali* but its index in the other nine Scincidae and the three *Lacerta* studied is given in Table 2. Since all the indices hover around 100 the bone is probably as wide as long in most of such forms. Where the index is greater than 100 the rise may be due to poor ossification of the median posterior limb resulting in a low figure for "length". The low indices for *Ablepharus boutonii* and *Lacerta pityusensis* may represent generic and specific differences respectively.

With regard to the two Anguidae in the series presented in this paper my findings differ somewhat from those given in earlier literature. In *Anguis fragilis* the interclavicle is reported by Fürbringer (1870) to be a variable nodule, sometimes cruciform (Krieg, 1919). But I failed to find any trace of an interclavicle for this species (Fig. 22) as did Cope (1892b). In *Ophoides striatus* the interclavicle is roughly anchor-shaped; the straight side arms making about a 65 degree angle with the longitudinal axis. The free extremities of these side arms extend to and slightly overlap ventrally a process of the scapulo-precoracoid formation. The median posterior pillar of the interclavicle tapers slightly toward the free end and is longer than it appears in Cope's (1892b) figure and more closely resembles that of Fürbringer (1870).

THE STERNUM AND XIPHISTERNUM

The usual description of the lizard sternum as a subrhombic plate of calcified cartilage seems adequate. Its antero-lateral margins usually touch and sometimes overlap ventrally the postero-medial edges of the precoracoids. The postero-lateral margins of the sternum are contacted by ribs from vertebrae 9, 10, and 11 respectively. In the series given in Table 1, this position of the sternum is maintained until we come to *Ophiodes striatus* where the sternum has moved forward and is in contact with ribs from vertebrae 7, 8, and 9. (I failed to detect any sternum at all in *Anguis fragilis*, Fig. 22). This change to a more forward position of the sternum on the part of the snake-like lizards was pointed out by Sewertzoff (1931). A study of Table 2 will show that

another change occurs in the sternum of these forms. If for purposes of comparison we assume that the *Lacerta* represent the "normal", then the normal sternum must be a plate as wide as it is long. The general trend in the degenerating Scincidae in the table appears to be toward a higher index indicating an increase of width over length. I believe this to result from a progressively increasing failure of the anterior margin of the sternum to calcify resulting in a hollowed out anterior edge (Figs. 17, 20, 19).

With regard to the sternal fontanelles, Camp (1923) regards them as having taxonomic value. This may be true but I cannot see that they have any particular evolutionary significance. In the forms studied for this series (Table 1) a single fontanelle was found in the sternum of *Lacerta erhardi*, *Eumeces skiltonianus*, *Chalcides tridactylus* and *C. striatus* (Figs. 12, 20, 19). But in none of the others was any trace of an opening detected. As already mentioned, I failed to find any sternum in *Anguis fragilis* but a remnant of the sternum was reported for this species by Cuvier (1825), Dumeril and Bibron (1835), Fürbringer (1870), Cope (1829b) and Sewertzoff (1931). No sternum occurs in *Anniella pulchra* or in *Acontias percivali*.

When Camp (1923) concludes that both the sternum and xiphisternum are formed by the fusion of the anterior parasternal bars, he does so only after having set forth almost incontrovertible evidence to bear upon this point. The present investigation lends additional weight for the support of his thesis. If the sternum and xiphisternum arise by fusion of the anterior of the parasternal bars it is conceivable, on the basis of a commonly accepted evolutionary theory, that when these structures degenerate they again come to resemble the parasternalia from which they originated. Bogoljubsky (1914) held that the xiphisternum arises as a paired structure in the embryo of *Lacerta*. Camp has shown that when this structure is "on its way out" it comes to resemble the parasternalia. From the figures given in this paper, the changes from the former extreme to the latter can be illustrated by studying the illustrations in the following order:

Lacerta erhardi (Fig. 12)
Eumeces skiltonianus (Fig. 15)
Brachymeles gracilis (Fig. 14)
Chalcides sepsoides (Fig. 17)
C. tridactylus (Fig. 26)
C. striatus (Fig. 19)

The two completely separated rods of *Lacerta erhardi* are fused at either end in *Eumeces skiltonianus* to form an elliptical structure. This is a solid formation in *Brachymeles gracilis* which is shortened and has a posterior opening in *Chalcides sepsoides*. In *C. tridactylus* it has separated into an anterior and a posterior half; each half strongly resembling the more posterior parasternalia. In *C. striatus* the anterior remnant is further reduced to a simple straight rod. The posterior part is hardly distinguishable from the other parasternalia. In general this change is seen to accompany limb reduction and increase in length of the trunk portion of the vertebral column.

In those forms among the Scincomorpha which are changing toward a burrowing habitus there is evidently an increase in number of parasternal bars as degeneration progresses. An illustration of this is plainly evident among the

ten skinks listed in Table 2. In *Eumeces* and *Ablepharus* there are 1 complete and 1 incomplete parasternalia. In *Brachymeles* there are 4 complete and 6 incomplete parasternal ribs. In *C. tridactylus* there are 9 complete and traces of 4 others while *C. striatus* has 9 complete ones with traces of 1 other. In the altogether limbless *Acontias percivali* there are 23 parasternalia.

Camp (1923) found no parasternalia present in degenerate Anguidae, Anniellidae, or Pygopodidae. However, as far as I can see in the specimens which I have examined, the parasternalia are cartilage rods, sometimes calcified, that are directly connected with the distal ends of the ribs. And in the pygopodids, *Lialis jicari* and *Delma fraseri*, I found such formations to be present. In *L. jicari* there are short projections of calcified cartilage from the distal ends of the ribs. The calcified portions are short and not continued far enough ventrad to meet their partners from the opposite side. But from the third anterior ribs, these projections are longer and extend ventrad far enuogh to contact the vestigial sternum on either side. The condition in *D. fraseri* is quite similar except that it is the projections from the fourth anterior ribs which contact the sternum in a sort of xiphisternal formation.

In regard to the homology between the abdominal ribs of these lizards and those found in *Sphenodon* and alligators, Hyman (1942) says that the latter two have abdominal ribs of dermal origin (gastralia) while those of the former are endo-skeletal in origin (parasternalia). This is in contradiction to Camp who holds that the abdominal ribs are homologous in lizards, *Sphenodon*, other reptiles and amphibians and that they are true abdominal ribs, parasternalia. The difference expressed here is more apparent than real. An examination of an alligator skeleton reveals the presence of rods of calcified cartilage in direct connection with the distal ends of ribs—parasternalia. But the alligator also has paired bony rods more posteriorly located on the abdomen and not in direct contact with the ribs. These are the gastralia. Keeping this distinction in mind, we find Camp's statement to be correct.

THE CORACOID

It is difficult to say when the last word concerning the coracoid question will be written. In the entire field of morphology few questions have invited the research and speculation that have grown up around the coracoid controversy. The principal points involved might be reduced to these two questions. How many elements were involved in the primitive tetrapod girdle? Which of these is homologous to the coracoid element in recent reptiles and which is homologous to the coracoid process of mammals?

With regard to these two questions most morphologists agree that there is only a single coracoid element in modern reptiles—the precoracoid, homologous with the single element found in the Permian reptiles, *Seymouria* and *Varanops*. Williston (1911) contends that a more posterior element already had been lost in these early forms. Williston thus comes to the same essential conclusion as Gregory (1918) and Hanson (1920) that the precoracoid of modern reptiles is homologous to the coracoid process of mammals. Watson (1917) holds that the Permian reptiles had not yet acquired a second, posterior

coracoid ossification. This, he argued, appeared later and in the mammal-like reptiles steadily grows while the precoracoid diminishes to be eventually lost. Watson agrees with Broom (1912), Hyman (1942) and Romer (1945) that the ossification in the coracoid cartilage of lizards and other reptiles being the precoracoid, it is not the homologue of the coracoid process of mammals.

All of the criteria used by the above mentioned investigators for the establishment of homologous bony elements are said to be insufficiently reliable by Howell (1936). He contends that the primitive tetrapod condition was a single paraglenoid ossification which developed in three directions: dorsad, craniad, and ventrad. The area of bone giving rise to the coracohumeral group of muscles may be called the anterior coracoid, and the part giving rise to the coracobrachial group, the posterior coracoid. On the basis then of the presence of these two muscle groups, Howell concludes that in the living lizard-like reptiles there are anterior and posterior coracoid areas, not merely a single one as is generally believed. Howell reports that in a private communication from Gregory the latter mentioned that he had come to recognize the posterior coracoid to be present in modern reptiles in an undivided condition.

Because the opinions expressed by Howell have not been generally accepted and since all of the above mentioned investigators (except Gregory in his communication to Howell already noted) agree that in reptiles the ossified area ventral to the glenoid fossa represents a single bone, the precoracoid, I have held to that terminology in this paper.

In all the forms investigated for this present study (except the most degenerate ones) the precoracoids for the Scincidae, Anguidae, and *Lacerta* are remarkably alike, differing only in size (Figs 12, 15, 30).

The precoracoid is a formation of bone and calcified cartilage. The cartilaginous portion extends forward to the clavicles in *Lacerta* and also in the first several skinks in the series. The mesial edge of this bone from each half of the girdle meet at the midline. Laterally the ossified portion is narrow where it joins the scapula in the formation of the glenoid cavity but toward the midline this bony area is expanded in an antero-posterior direction. There is but a single complete fenestra which is enclosed anteriorly by calcified cartilage. Between the posterior margin of this fenestra and the glenoid fossa is the large supracoracoid foramen. The scapulo-coracoid fenestra is represented by an open emargination. Thus the bone is not at all like the solid plate figured by Fürbringer (1870) for *C. tridactylus*.

The shoulder girdles of *Ophiodes striatus* and *Anguis fragilis* have the precoracoid indistinguishably fused to the scapula; there being neither suture nor glenoid cavity to separate the two. In *O. striatus* there is still a forward jutting process of the precoracoid which extends under the arm of the interclavicle which in fully developed forms would set off the scapulo-precoracoid emargination (Fig. 30). There is no calcified cartilage area connected with the precoracoid in *O. striatus*. The complex is even further reduced in *A. fragilis* (Figs. 22, 30). The scapulo-precoracoid is a straight transversely placed bone somewhat expanded at either end. In *Anniella pulchra* and *Acontias percivali* a tiny pair of cartilaginous rods placed far forward are the only vestiges of

a pectoral girdle. A number of earlier investigators, notably Coe and Kunkel (1906), reported no trace of a pectoral girdle for *Anniella pulchra* but, as did Camp (1923), I found a pair of small, narrow rods of calcified cartilage quite similar in shape and position to the remnants of the shoulder girdle in *Acontias percivali* (Fig. 16). In *Anniella* the anterior and more dorsal end of each rod lies just ventral to the distal end of the first rib. Separated from it but very close to the forward end of the cartilaginous rod on the left side, is a tiny circular ossification. On the right side this is connected to the rod and is more oblong than round. There seems little disagreement with the thesis that the shoulder vestiges in *Acontias* represents scapulo-precoracoid remains. But in *Anniella pulchra,* Camp (1923) holds that the paired remnants represent the clavicles. He argues that muscle attachments are those of the clavicle and that in the Anguimorpha the degenerating clavicle lags behind the other elements of the anterior girdle. There is one thing about such a contention that should be pointed out. The clavicles of *Ophiodes, Ophisaurus,* and *Anguis* have their medial ends pointing antero-ventrad whereas the inner ends of the paired bars of cartilage in *Anniella* point postero-caudad, i.e., the position of the longitudinal axis of the vestige with reference to the long axis of the animal's body is changed. Such a position is more natural to the scapulo-precoracoid remains. And, as Camp concedes, it is possible that shifting of muscle insertions has occurred during degeneration.

Together with Broom (1907), Camp (1923) and Howell (1936) I am of the opinion that the calcified cartilaginous border of the precoracoid is but the unossified portion of the embryonal scapulo-precoracoid anlage and does not represent a separate bone. However, it is frequently labeled "epicoracoid" and it forms a wide expanse anteriorly which extends posteriorly to contact the antero-lateral edges of the sternum.

THE SCAPULAE

Throughout the *Lacerta* and Scincidae examined, the scapulae were quite similar; except where degeneration was far advanced as in *Acontias percivali.* The scapula is a roughly triangle-shaped bone with the apical end joining the precoracoid in the glenoid fossa. The scapula lies chiefly in the antero-posterior direction and is only slightly inclined dorsad (Fig. 26). Its Distal end is considerably broadened and contacts the suprascapula all along that edge. The medial end of the distal border is somewhat prolonged in *Brachymeles gracilis* (Fig. 29). In *Chalcides ocellatus* and *C. sepsoides* there is a small piece of calcified cartilage attached to the median side of the anterior end of the scapula. If this were extended it would close anteriorly the scapulo-precoracoid emargination (Figs. 17, 18). In the two Anguidae in the series the scapula together with the precoracoid forms a single bone and was described above.

THE SUPRASCAPULAE

Suprascapula is the name given to designate that formation of calcified cartilage which constitutes the most dorsal element of the pectoral arch. Proximally it contacts the scapula but distally it ends freely on the dorsal surface of the body near the vertebral column. This free dorsal edge is considerably expanded and is irregularly notched and eroded (Figs. 13, 18).

All of the species examined for the morphological series studied here had well developed suprascapulae except *Acontias percivali* and *Anniella pulchra.* In the Scincidae the main body of the element lies at right angles to the scapula while in the Anguidae it lies in the same plane as the scapulo-precoracoid. On the anterior edge near the scapula is a small forward projecting point which serves to contact the clavicle in the Scincidae and *Lacerta.* This is labeled the "acromion" process by Krieg (1919) (Figs. 13, 10). In the Anguidae the lateral end of the clavicle lies outside the suprascapula for most of its length. In *Chalcides sepsoides, C. tridactylus,* and *C. striatus* the suprascapula is joined by a narrow strip of calcified cartilage to the calcified cartilaginous portion of the precoracoid, forming a single unit with it (Figs. 10, 18).

The Pelvic Girdle

THE PUBES

Of the two pairs of elements which comprise the ventral portion of the pelvic girdle of lizards, the pubes form the most anterior pair. Each pubis is a slender bone throughout most of its length but it is considerably widened postero-laterally where it joins the other pelvic elements in the formation of the acetabulum. From the acetabulum the pubis is directed craniad and toward the midline. In forms in which there is is no degeneration of the girdle (Fig. 24) each pubis, by means of a ligament, joins its partner at the midline in the pubic symphysis. In the forms observed for this series, the two pubes meet at almost a right-angle to enclose a heart-shaped vacuity, the puboischiac foramen.* At a point almost one-fourth of its length from the acetabulum, each pubis from its external border gives rise to a bluntly pointed process, the pectineal process. This process is directed mediocaudad. The broader expanse of the pubis is pierced by the pubic foramen giving passage for the obturator nerve. The foramen is sometimes wholly or partially obscured by the overhanging pectineal process (Fig. 24).

In taking the measurements for Table 1, it was discovered that the pubis was consistently the longest of the three pelvic bones until *Chalcides tridactylus* was reached in which species the ilium and pubis were of equal length. From this point downward in the series, the pubis was shorter than the ilium. However, in *Anniella pulchra* and *Acontias percivali* it is impossible to distinguish the separate elements of the pelves. The absence of the pubic and ischiac symphyses marks the beginning of pelvic degeneration and, as Fürbringer (1870) has shown, this sometimes occurs before any degeneration of the posterior limb is manifest. An examination of Figs. 24, 26, 25, and 33 ,will show some probable stages in the degeneration of the pubis. The bone seems first to shorten and become ever more widely separated from its partner at the midline. The pectinal process becomes increasingly smaller and is completely gone in *Chalcides striatus.* In *Ophiodes striatus* the pubes are very narrow and curved slightly and without pectineal processes (Fürbringer, 1870, states the latter to be present). In *Anguis fragilis* (Fig. 33) the pubis is rep-

* Hyman (1942) suggested that the term obturator foramen be reserved for the vacuity which represents a fusion of the pubic and puboischiac foramina.

resented by a short projection from the region of the acetabulum toward the midline. There is neither pectineal process nor pubic foramen.

THE ISCHIA

The ischium is the shortest and broadest of the three bones forming each half of the pelvic girdle. Where there is no reduction (Fig. 24) the two ischia form a pair of transverse plates meeting at the midline in the ischiadic symphysis. The absence of this symphsis marks the initial stages of reduction in the ischia. On its posterior border, near the proximal end, each ischium exhibits a prominent posterior projection, the tuber ischii. Various stages in the degeneration of the ischia are suggested by Figs. 24, 26, and 25. Notice that the posterior part of each ischium, between the tuber ischii and the medial end, disappears leaving a shortened obliquely directed rod tipped with calcified cartilage. The tuber ischii persists through the final stages of reduction until, as in *Anguis fragilis* (Fig. 33), the ischium is represented by only a very short process.

THE EPIPUBUS AND HYPOISCHIUM

In the median line of the pelvis lies a strand of fibrous cartilage which is continued forward to the wedge-shaped formation of calcified cartilage, the epipubis, and backward to the hypoischium. Camp (1923) calls attention to the fact that in adult material the hypoischium appears to be a posterior continuation of the symphyseal ligament. This seems to be equally true for the epipubis as a forward continuation of the ligamentum medianum. The embryological studies of Mehnert (1891) however, show that there is no developmental relation between the ligamentum medianum and the calcareous epipubis and hypoischium. According to Mehnert the hypoischium originates as a knob of cells on the distal end of the anlage of the ischium. These two clusters of cells fuse and their continuity with the ischium proper is broken by the formation of separating connective tissue. The epipubis originates in the same manner as a cellular protuberance on the end of each pubic anlage.

In *Ophiodes striatus* (Fig. 32) each pubis terminates medially in a thin rod of partially calcified cartilage which Cope (1892b) questioningly designates as epigastroid (epipubis). Camp (1923) claims that the epipubic bone exists in a paired condition only in the Varanidae among the lizards. Since the pelvis of *O. striatus* is unquestionably degenerate, it would seem that the cartilage strands represent unossified termini of the pubes. The epipubis is described by Hyman (1942) as lying in front of the pubic symphsis. If this location is a criterion *sine qua non*, then I have found the epipubis to exist only in *Cnemidophorous*. But I believe the "stop-gap" formation between the medial ends of the pubes in *Chalcides* (Figs. 24, 25, 26) to be epipubis. Without sectioning, one cannot tell whether a formation is cartilage or a symphyseal ligament. Either could calcify and a ligament, like a tendon, may even ossify. In the prepared specimens, the bar connecting the medial ends of the pubes is stained indicating the presence of inorganic salts. In the case of calcified cartilage the deposition is somewhat irregular and can be distinguished quite readily from bone in which the deposition of salts is more compact and uniform. If this criterion is in itself sufficient to differentiate between calcified

cartilage and a possible partial ossification of the ligament, then the structures in question are cartilaginous epipubes.

Only in *Ophiodes striatus* of the morphological series here presented, is there a structure one might term hypoischium. In *O. striatus* there is a conspicuous "V"-shaped formation of calcified cartilage directed backward below the widely separated ends of the ischia (Fig. 32). This is the "cartilago cloacalis" of Fürbringer 1870 which he and Cope (1892b) describe as having the form of a letter "Y" rather than that of the "V" formation which I have found. If this is a true hypoischium, it would seem to uphold Mehnert's contention that the structure originates in two parts which Camp (1923) doubts, suggesting that "the element is only an epiphyseal calcareous deposition in the ligamentum hypoischium".

THE ILIA

In a morphological series of progressively degenerate forms, the ilium exhibits the greatest stability of the pelvic elements. That the reduction of the ilium lags behind the other bones of the pelvis was pointed out by Fürbringer (1870). From the acetabulum the normal ilium is directed dorso-caudad. In the completely limbed forms in this series the distal fourth of the bone has a more posterior bend and is broadened slightly. This is the portion which is firmly bound by ligaments to the transverse processes of the sacral vertebrae (Figs. 23, 34, 31) thus giving rigidity for the stresses and strains the pelvis must bear in the limbed forms. In *Ophiodes striatus* and *Anguis fragilis* the pubes and ischia are much reduced but the ilia have quite normal proportions and still retain contact with the spinal column (Figs. 34, 31).

The vestiges of the pelvis which are found in *Anniella pulchra* and *Acontias percivali* (Figs. 27, 28) I believe to be ilia. Each bone is a single element; there being no trace of sutures. The position is that of the ilium i.e., the distal tip is near the transverse process of a sacral vertebra from which point the remnant extends medio-craniad. Then, as has already been said, the ilium is the last of the pelvis to show marked reduction. My findings for the vestigial pelvis of *Anniella pulchra* are in complete agreement with the observations of Coe and Kunkel (1906). The vestige found in *Acontias percivali* is similar but somewhat smaller, not extending so far ventrad. It probably represents a further stage of the reduction of the pelvis shown by *Acontias meleagris* (Fürbringer, 1870). It has been argued by Böker (1937) that the complete reduction of an organ is sometimes prevented, or at least delayed, as long as that organ has even a secondary or subsidiary function. He gives the vestigal pelvis as an example. After the disappearance of the hind limbs, the pelvis has no locomotory function. But the remnants are secondarily useful as supporting structures for the cloaca.

Discussion of Tables 1, 1a and 2

In Tables 1 and 2 we have a fairly comprehensive schema of the changes in size relationships occurring in the osteology of a group of lizards undergoing limb reduction. In order to better understand these tables a few words are necessary to explain how they were prepared.

TABLE 1.—Indices* of trunk, limbs and elements comprising pectoral and pelvic girdles.

Species	Trnk.	Leg	Arm	Clv.	Iclv.	Strn.	Scp.	Sscp.	Pcor.	Ilm.	Isch.	Pbs.	No. prescrls.
Eumeces anthracinus	28.6	60.0	85.7	200	266	240	400	400	266	240	400	240	26
Ablepharus boutonii	26.5	47.2	60.7	240	212	243	566	340	283	283	377	243	27
Eumeces skiltonianus	30.6	61.5	88.8	254	266	320	533	400	320	287	400	266	28
Brachymeles schadenbergii	16.6	71.4	115.0	214	187	300	428	375	250	230	375	200	32
B. gracilis	19.1	81.8	138.0	240	225	276	450	500	300	276	400	225	34
Chalcides o. ocellatus	17.6	66.6	81.4	200	211	300	450	360	257	240	360	225	37
C. sepsoides	16.4	68.7	168.0	275	293	366	550	366	550	314	440	244	46
C. tridactylus	13.3	143.0	200.0	270	287	333	666	500	500	333	500	333	58
C. striatus	13.4	137.0	182.0	275	293	440	733	440	550	293	440	314	59
Anguis fragilis**	8.1	.....	.....	280	.....	.....	933	560	700	350	933	430	65
Ophoides striatus**	10.7	215.0	.....	215	400	560	1100	622	1200	311	560	311	66
Anniella pulchra**	8.8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	73
Acontias percivali	10.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	76
Lacerta pityusensis	31.5	46.1	72.0	225	225	300	600	450	300	300	450	200	27
L. erhardi	29.4	41.6	71.4	250	230	300	500	500	300	300	500	250	25
L. sicula	31.9	45.4	78.9	300	214	300	500	428	375	333	375	230	26

* Indices were determined by the ratio of the skull length to the length of each part indicated in the table multiplied by 100.

** The species thus indicated belong to the section Anguimorpha, the others to the section Scincomorpha.

Abbreviations: Clv.—clavicle, Iclv.—interclavicle, Ilm.—ilium, Isch.—ischium, No. prescrls.—Number of presacrals, Pbs.—pubis, Pcor.—precoracoid, Scp.—scapula, Sscp. suprascapula, Strn.—sternum, Trnk.—trunk.

The first 13 species in Table 1 are arranged from top to bottom in the order of increase in the number of their pre-sacral vertebrae. This arrangement was used because of Sewertzoff's (1931) demonstration of the correlation between the number of pre-sacrals and degenerative changes accompanying the assumption of a burrowing habitus. In this present series, ten of the species are from the family Scincidae because of this close relationship, I believe that comparisons made within the series will be more valuable than were those of Sewertzoff;* the members of his series were not so closely related within a single family. In column fourteen, at the extreme right of the table, is given the number of pre-sacral vertebrae for each species listed in column one. Where a distinct sacrum was lacking, the number of "pre-pelvic" vertebrae was substituted; this appears acceptable since the pelvis shifts its position with the sacrum where the latter yet remains.

When it is desirable to compare homologous structures which appear to be undergoing change, it becomes necessary to choose, as a basis for comparison, a structure which is either not changing at all; or at least not so fast as the other elements. After some deliberation concerning the choice of this relatively more stable structure, I decided to take the skull. Each index then appearing in the table was arrived at by taking the ratio of the skull-length to the length of the respective parts and elements listed across the top of the table and multiplying the result by 100. Table 1a gives the lengths in mm. of the structures listed in Table 1.

Under the second heading from left to right are found the trunk indices. The length of the trunk was taken as the distance between the atlas and the sacrum (or the pelvis). Even a cursory glance at this column shows that the indices gradually diminish indicating that the length of the trunk in relation to the length of the skull generally increases as the number of pre-sacral vertebrae increases. Under the other headings the trend is not so obvious but a close inspection reveals that the indices are greater as the number of pre-sacrals increases. As we read down a column we notice that whenever a new genus is introduced there is a reoccurrence of a lower figure. Then a rise in the index continues as long as the species are within the same genus. A good example of this tendency is to be found in the indices for the pubis. (Text Fig. 1). The genus *Brachymeles* has a smaller index than has the genus *Eumeces*. The second species of *Brachymeles i.e., gracilis* has a higher index than has *B. schadenbergii*. Then the first species of *Chalcides i.e., ocellatus* has the same pubic index as has *Brachymeles gracilis*. The index then steadily rises through the next three species of *Chalcides*. The genus *Anguis* which follows proves exceptional by having a higher index than any of the preceding. But *Ophiodes*, the last in the column, has a pubic index smaller than *Anguis* and more closely approaches the index of *Chalcides striatus*. It would seem then that each genus has a characteristic index level which may indicate that each is going along the pathway of degeneration at its own rate

* Sewertzoff's series is as follows: *Scincus officinalis, Eumeces schneideri, Lygosoma punctulatum, Chalcides ocellatus, C. sepsoides, Typhlosaurus, Ophiomorus tridactylus, Seps chalcides, Ophiodes striatus, Ophisaurus apus,* and *Anguis fragilis.*

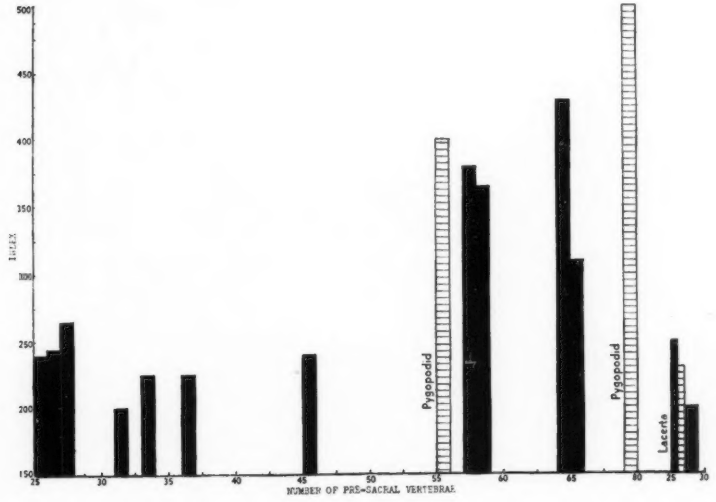
TABLE 1a.—Length in mm. of trunk, limbs and elements comprising pectoral and pelvic girdles.

Species	Trnk.	Leg	Arm	Clv.	Iclv.	Strn.	Scp.	Sscp.	Pcor.	Ilm.	Isch.	Pbs.	No. prescrls.
Eumeces anthracinus	42.0	14.0	20.0	6.0	4.5	4.5	3.0	3.3	4.5	5.0	3.0	5.0	26
Ablepharus boutonii	32.0	14.0	18.0	3.3	4.0	3.5	1.3	2.5	3.0	3.0	2.3	3.5	27
Eumeces skiltonianus	26.0	9.0	13.0	2.7	3.0	2.5	1.2	2.0	2.5	2.7	2.0	3.0	28
Brachymeles schadenbergii	90.0	13.0	21.0	7.0	8.0	5.0	3.5	4.0	6.0	6.0	4.0	7.5	32
B. gracilis	47.0	6.5	11.0	4.0	4.0	3.5	2.0	1.5	3.0	3.2	2.2	4.0	34
Chalcides o. ocellatus	102.0	27.0	22.0	9.0	8.5	6.0	4.0	5.0	7.0	7.5	5.0	8.0	37
C. sepsoides	67.0	6.5	16.0	4.0	3.7	3.0	2.0	3.0	2.0	3.5	2.5	4.5	46
C. tridactylus	75.0	5.0	7.0	3.7	3.5	2.0	1.5	2.0	2.0	3.0	2.0	3.0	58
C. striatus	82.0	6.0	8.0	4.0	3.7	2.5	1.5	2.5	2.0	3.7	2.5	3.5	59
Anguis fragilis*	173.0	.....	.....	5.5	....	....	1.0	2.5	2.0	4.0	1.5	3.2	65
Ophoides striatus*	130.0	6.0	.....	7.0	3.5	2.5	1.2	3.2	1.0	4.5	2.5	4.5	66
Anniella pulchra*	102.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	73
Acontias percivali	79.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	76
Lacerta pityusensis	52.0	21.0	36.0	6.0	6.5	5.0	3.0	3.0	4.5	5.0	3.0	6.0	27
L. erhardi	57.0	25.0	37.0	8.0	8.0	6.0	3.0	4.0	6.0	6.0	4.0	9.0	26
L. sicula	47.0	19.0	33.0	5.0	7.0	5.0	3.0	3.5	4.0	4.5	4.0	6.5	26

* The species thus indicated belong to the section Anguimorpha, the others to the section Scincomorpha.
See Table 1 for abbreviations.

with an occasional detour by some or stop-overs by others along the way. Specimens 10, 11, and 12 in the series are anguimorphs but seem to fit quite well into the series, the rest of which is made up entirely of scincomorphs. Generally speaking it can be said that species with about the same number of presacral vertebrae are at a parallel stage with regard to other degenerative changes. Yet specimens 10 and 11 in the table, which have 65 and 66 presacral vertebrae respectively, are at markedly different stages of retrogression. Both are Anguidae but the first, *Anguis fragilis*, has neither limbs nor interclavicle nor sternum. The second, *Ophiodes striatus*, has vestigal hind limbs as well as interclavicle and sternum (Figs. 22, 30). It is interesting to note in this connection that two cleared pygopodids which I have on hand, *Delma fraseri* and *Lialis jicari*, with 56 and 92 pre-sacral vertebrae respectively, each retains a good though poorly calcified sternum but no interclavicle. These two anguimorphs are quite definitely grass-dwelling types and probably had a definitely different evolutionary course from their burrowing relatives.

The blank spaces occurring in the columns of Table 1 after specimens 10, 12, and 13 do not necessarily indicate that the part in question is completely lacking but that it may be so small or so fused with other remnants that measurement was a physical impossibility. A study of Table 1 suggests that after a certain stage is reached in this retrogressive process, before the number of pre-sacrals reaches 70, the disappearance of the girdle elements occurs quite rapidly and completely. Yet the snake-like, grass-inhabiting *Lialis jicari* with 92 pre-sacral vertebrae retains most of the girdle elements in easily distinguishable form. Do the parts retained here function longer in this mode of progression than in burrowing? On the whole the indices tabled substantiate



Text Fig. 1.—Graphic representation of pubic indices given in Table 1.

Fürbringer's (1870) thesis that in the process of becoming "snake-like" the separate elements of the limbs and girdles shorten and may eventually disappear—this reduction occurring more rapidly in the limbs than in the girdles. The rule of inverse sequence (Sewertzoff, 1931) appears equally true; that is, the part first disappears in the ontogeny which in normal ancestors would be laid down last.

At the bottom of the table are the indices for three species of *Lacerta*. These are given as a basis for comparisons because they represent a relatively more stable group of scincomorphs (Species 14, 15, 16 in Text Figs. 1, 2). I also believe that they represent a fairly primitive group although according to Camp (1923) they do not retain as many primitive characters or have such paleotelic weight as do the Scincidae. Yet Camp does say, in particular reference to the genus *Lacerta,* that a number of fossil species have been referred to this genus; some from as far back as the Eocene. Examination of the indices given for these *Lacerta* show a fairly close approximation to one another for a given part. Yet the differences are greater than could be expected on the basis of chance alone and probably point to species differences. In comparing the indices for the *Lacerta* with the indices for similar structures of the preceding species in the table, we note that the indices of those with similar numbers of pre-sacral vertebrae are more nearly alike. This is not true particularly for the indices of scapula and ilium. These bones seem to be relatively shorter for the *Lacerta* than they are for the skinks with the same number of pre-sacrals.

In compiling Table 2, I have attempted to discover what changes may have occured in the relative proportions of certain structures in forms undergoing degenerative changes. The index in each case was determined by the ratio of the greatest width to the greatest length multiplied by 100. As in Table 1 the indices for the three species of *Lacerta* are given at the bottom of the table as examples of a more stable group for purposes of comparison.

The skull indices appear very irregular and no evidence of periodicity can be gathered from this data. Perhaps the ratio of the width of the skull to its length has no bearing on the changes involved in becoming "snake-like". But with the exception of *Brachymeles schadenbergii* (fourth in the series) all of the Scincidae in the table have skull indices less than the three species of *Lacerta*. The significance of the indices of the other elements given in the table has already been considered as each part of the girdles was discussed separately.

General Discussion

A very widespread view of the evolutionary process is expressed in the following quotation from Dampier (1944):

> "Darwin proved that Nature herself uses the method of empirical experiment—she tries all possible variations and, out of countless trials, succeeds in a few cases in establishing

TABLE 2.—Indices* showing changes of proportion in certain structures in a morphological series of lizards.

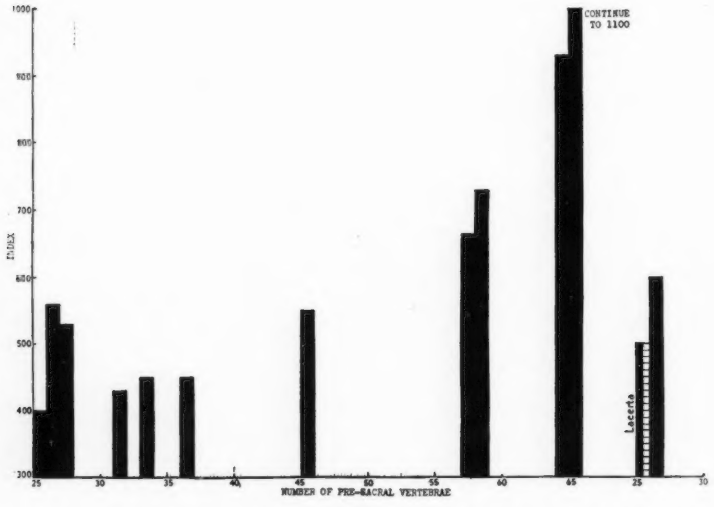
Species	Skull			Interclavicle			Clavicle			Sternum			No. Pre-scrls.
	Index	Length	Width	Index	Length	Width	Index	Length	Width	Index	Length	Width	
Eumeces anthracinus**	75.0	12.00	9.00	133	6.00	4.50	25	6.00	1.50	122	4.50	5.50	26
Ablepharus boutonii	58.8	8.50	5.00	62	4.00	2.50	46	3.25	1.50	71	3.50	2.50	27
Eumeces skiltonianus	62.5	8.00	5.00	100	3.00	3.00	45	2.75	1.25	80	2.50	2.00	28
Brachymeles schadenbergii	86.6	15.00	13.00	100	8.00	8.00	43	7.00	3.00	120	5.00	6.00	32
B. gracilis	55.5	9.00	5.00	100	4.00	4.00	46	3.75	1.75	69	3.00	2.75	34
Chalcides o. ocellatus	75.0	18.00	13.50	117	8.50	10.00	33	9.00	3.00	133	6.00	8.00	37
C. sepsoides	63.6	11.00	7.00	133	3.75	5.00	31	4.00	1.25	125	3.00	3.75	46
C. tridactylus	70.0	10.00	7.00	100	3.50	3.50	20	3.75	0.75	150	2.00	3.00	58
C. striatus	65.9	11.00	7.25	113	3.75	4.25	18	4.00	0.75	160	2.50	4.00	59
Acontias percivali	75.0	8.00	6.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	76
Lacerta pityusensis	88.0	18.00	16.00	88	8.00	7.00	25	8.00	2.00	100	6.00	6.00	27
L. erhardi	87.0	15.00	13.00	100	6.50	6.50	29	6.00	1.75	110	5.00	5.75	26
L. sicula	87.0	13.00	15.00	100	7.00	7.00	30	5.00	1.50	100	5.00	5.00	26

* Indices were determined by the ratio of the width of each structure to its length multiplied by 100.
** The first ten species are members of the family Scincidae.
Measurements are given in millimeters.

> that new and greater harmony between the being and its environment from which evolution proceeds."

This would seem to imply the existence in each generation of many small variations; only those being preserved which had definitely selective value. This seems to be too limited a view of the evolutionary picture for the observations made by Sewertzoff (1931) on the snake-like lizards do not bear out the foregoing hypothesis. Particularly from careful studies of the development of *Ophisaurus apus*, he was convinced that the variation material from which phylogenetic changes proceed is somewhat different from that which is customarily assumed. He maintains that variations do not consist of small changes (mutations) but rather of two types of more significant changes. First there may occur alteration in the form (change from a caudal to a thoracic vertebra, in *Acontias percivali* for example). Second, there occurs quite regularly a coordinated variation within a species in the position of functionally connected organs (coordinated variations in the position of the sacrum, pelvis, rear extremities, cloaca, and characteristic scales bordering the vent). From the great number and variety of the snake-like lizards, we can see that coordinate, comparatively large variations are not rare "sports" but take place proportionately often. But, as Simpson (1947) says, "Once such a change has arisen, it is simply another bit of material for natural selection and its status is the same as any mutation except for its larger size, in terms of structural change".

The idea of "functional adaptation" was expressed by Haldane and



Text Fig. 2.—Graphic representation of scapula indices given in Table I.

Huxley (1929) as " . . . the adaptation of separate organs to the demands upon them through the effects of function upon growth." These authors ask us to consider any young organism, such as a puppy, which already possesses a characteristic organization but one which is plastic within wide limits. They point out that "the final shape and size of bones, muscles, sinews, tendons, glands, digestive tube, even of parts of its central nervous system, depend very largely upon the amount and kind of use to which they are put during development."

It is understood that in their treatment of functional adaptations, Haldane and Huxley were referring to specific morphologic changes within the ontogenetic development of individuals. But with certain changes and reservations, the idea has been extended by some observers to explain phylogenetic origins and development. In accordance with such a line of thought, some statements of Böker (1935--37) are interesting. He says that the changes occuring during the loss of limbs in snake-like forms must not be confused with the old "Lamarckian" concept of use and disuse of a part but they must be considered as an active reaction of an entire organism to a disruption of the "bio-morphological balance". The idea of a disorder in the "bio-morphological balance" is enhanced by Sewertzoff (1931) when he says that where an organ has lost its functional (biological) importance it may begin to be reduced. He maintains that if, on account of a change in the living conditions, such an organ never again becomes "functionally apt" then it always becomes further reduced to an unimportant vestige and finally disappears completely.

Another way of looking at this changing relationship between form and function is suggested by Simpson (1947). Such a thing as body length may be a selectively controlled adaptive structure which may proceed to the point where its use in a new way (locomotion) becomes possible. It is then "preadaptive" with respect to its new use and as long as this new use is advantageous, selection will tend to direct evolution in this new direction. Loss of limbs and other variations coordinate with increase of trunk length would tend to have the same evolutionary course.

To be of importance in explaining phylogenetic changes, any potentialities of the organism to react to functional stimuli must be of genetic quality. The impress of new needs arising from an alteration in living conditions is in itself not enough to mold irrevocably the animal form. It was pointed out by Camp (1923), for example, that among the Ascolobota there were many arboreal lizards showing highly specialized adaptations to a tree-dwelling existence (compressed bodies, prehensile tails, sucking laminae on the toes, lateral fringes, etc.). But within the Ascolobota there is never found the snake-like habitus which is so admirably adapted to sliding through the grass or burrowing in soft earth. Such grass-dwelling or burrowing types are found solely within the autarchoglossids. However, among the autarchoglossine lizards there are some that take to living permanently in trees but they do not show the typical arboreal habitus developed by the tree-dwelling Ascalobota. And, indeed, there are some highly terrestrial Ascalobota but they never become snake-like. The pressure of new needs arising from environmental changes is not enough in every case to bring about specific adaptations effecting phylogeny.

Evidently some latent potentiality to vary in certain directions must be present in the germ plasm. We might imagine the occurrence of a certain genetic constellation permitting a definite breadth of variation under proper conditions of environmental stimulus and natural selection.

Camp has noted the correlation between the presence of the rectus superficialis muscle and the occurrence of limblessness. The rectus superficialis is always present in the autarchoglossine lizards (rarely in the Ascalobota) and it helps along the action of the limbs in walking. Snake-like locomotion is possible to this group which has preserved a highly developed ventral locomotory musculature. Just as the capacity for changes in shape and size of organs is greater in young organisms, so perhaps the "variation-breadth" may be greater in early phylogeny only to become progressively limited as specializations increase. Primitively, lizards possessed an inherent plasticity which became fixed along definite lines in patterns produced by the stimuli of environmental changes and natural selection. The early loss of a highly developed belly musculature among some lizards may have prevented an entire group (Ascolobota) from developing toward a snake-like habitus.

Summary

1. A comparative study was made of the morphological changes occurring in the osteology of the limbs and girdles of the degenerate, snake-like lizards. For purposes of comparison a morphological series was set up on the basis of the increase of the number of pre-sacral vertebrae which accompanies the change from running-crawling to the typical snake-like locomotion. For the most part the study was confined to members of the family Scincidae with supplementation from observations made on some Anguidae, Pygopodidae, Lacertidae, and Anniellidae.

2. Specimens were cleared and stained according to a modified Schultze technique.

3. On the basis of the ratio of the length of the trunk to the skull it can be seen that the length of the trunk increases as the number of pre-sacral vertebrae increases. Similar ratios of the lengths of the limbs and of the girdle elements show that these structures shorten as the number of pre-sacral vertebrae increases. However, each genus appears to have a characteristic index level which rises in correlation with the increase in number of pre-sacral vertebrae. On the whole, it seems that species with about the same number of pre-sacral vertebrae are at a parallel stage with regard to degenerative changes. There are notable exceptions and there is evidence that the grass-dwelling types have a different evolutionary course from their burrowing relatives.

4. Data are supplied which substantiate the thesis that the primitive clavicle was a narrow rod which was followed by stages of increased expansion and perforation, succeeded by reduction and eventual disappearance in the snake-like lizards.

5. No interclavicle was found in the specimen of *Anguis fragilis* examined.

6. In the changes toward a snake-like habitus the sternum acquires a more forward position and in the Scincidae the ratio of its width to length becomes progressively larger as degeneration proceeds. No sternum was found in *Anguis fragilis, Anniella pulchra,* or *Acontias precivali.*

7. The view of earlier investigators that the xiphisternum arises as a fusion of the parasternal bars was substantiated by observations on primitive, intermediate and degenerate lizards.

8. In the Scincomorpha the number of parasternalia increases as degeneration proceeds toward complete limblessness. No completely formed parasternalia were found in degenerate Anguimorpha.

9. In degenerate forms the precoracoid is retained fused with the vestigial scapula as a single bone. I believe the paired remnants of the pectoral girdle found in *Anniella pulchra* to be the scapulo-precoracoid formation similar to the vestiges found in *Acontias percivali.* This is the last vestige of the pectoral girdle to be found in the extremely degenerate Scincidae. Among the Anguimorpha, particularly the grass-dwelling pygopodids, the pectoral girdle is retained in a more complete state in correlation with a high number of presacral vertebrae.

10. The ilium is the most stable element of the pelvic girdle and persists after the other elements have disappeared in such forms as *Anniella pulchra* and *Acontias percivali.*

11. The pubes are the longest of the three pairs of bones making up the pelvis. During degenerate evolution they gradually shorten and lose their pectineal processes.

12. The ischia are the shortest and broadest of the pelvic bones. In degeneration they become shorter and apparently become narrower by losing their posterior expansion.

13. An epipubus was found present in all of the forms examined except the most degenerate in the series. A hypoischium was found in none except possibly in *Ophiodes striatus.*

14. Theories were discussed regarding over-all evolutionary processes involved in the habitus changes of lizards that have become or are becoming snake-like.

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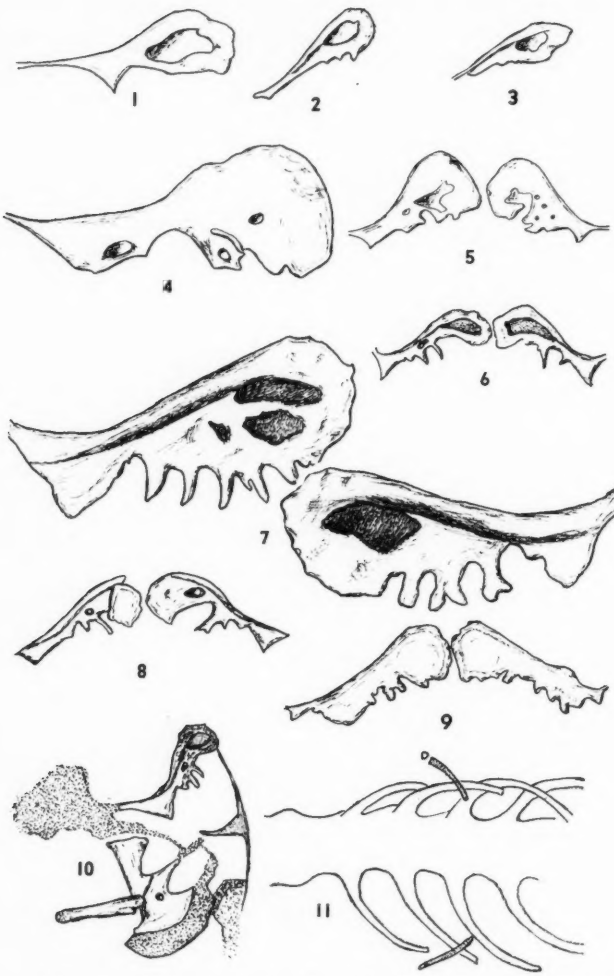
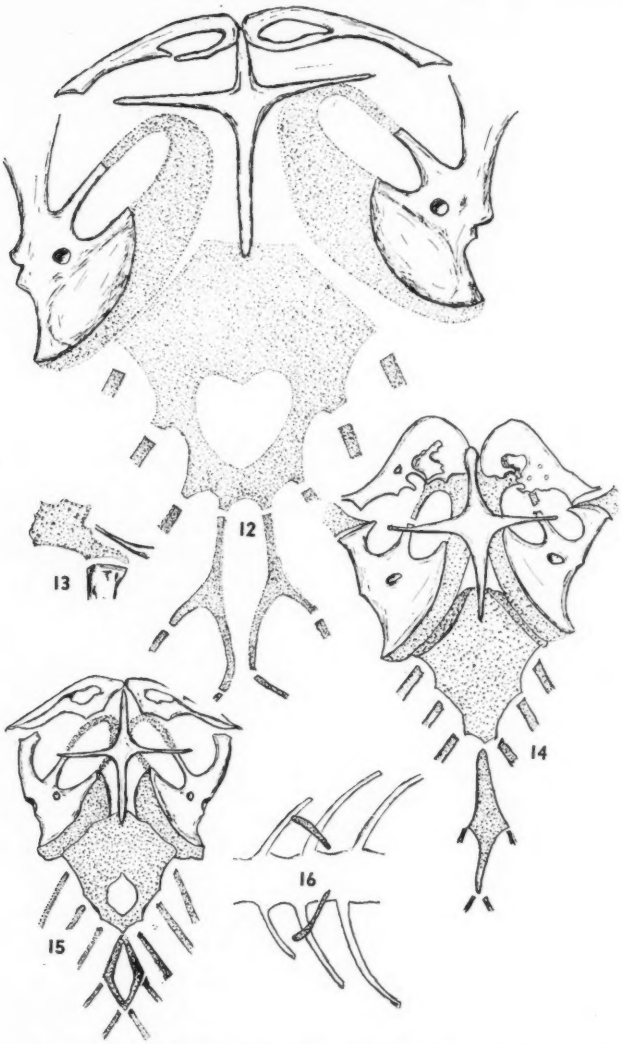
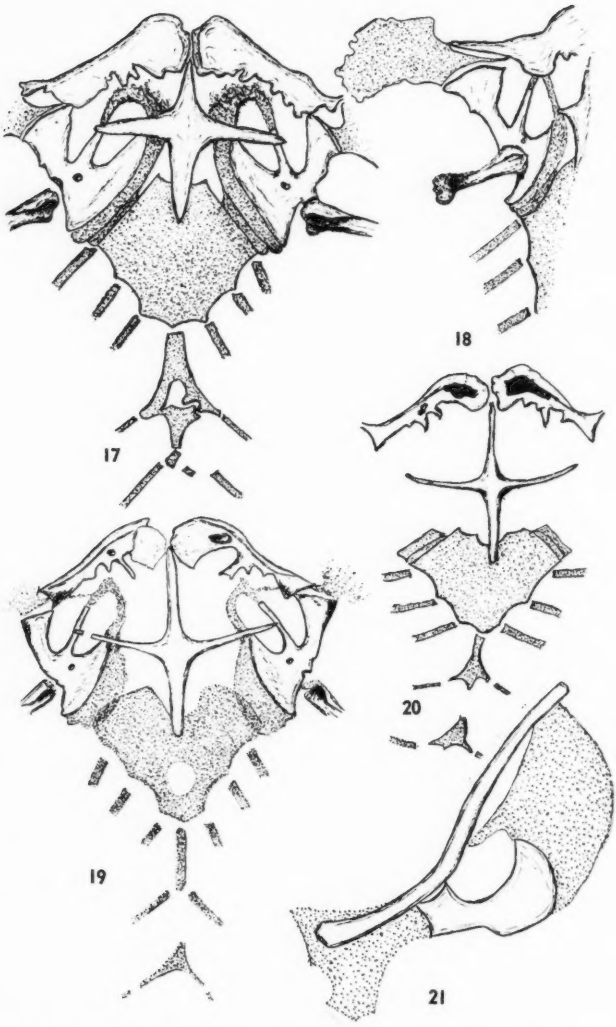


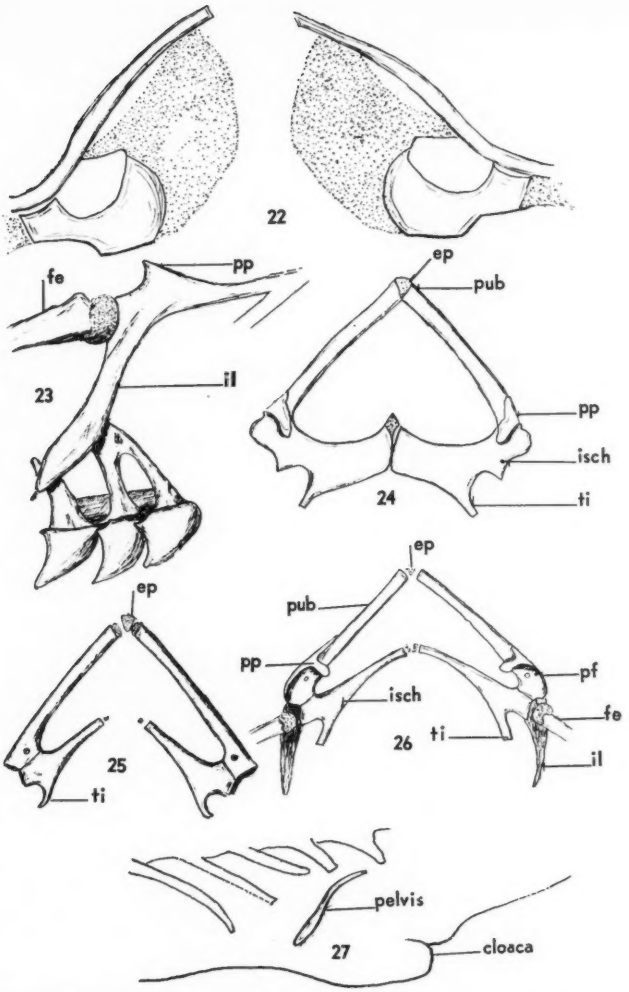
Figs. 1-11: Clavicles of degenerating Scincidae. Both clavicles are illustrated in cases of pronounced asymmetry otherwise only the right bone is portrayed (ventral view). 1. *Eumeces anthracinus*, 2. *Ablepharus boutonii*, 3. *Eumeces skiltonianus*, 4. *Brachymeles schadenbergii*, 5. *Brachymeles gracilis*, 6. *Chalcides tridactylus*, 7. *Chalcides. o. ocellatus*, 8. *Chalcides striatus* (The median end of the right clavicle is broken and replaced), 9. *Chalcides sepsoides*, 10. Right half of the shoulder girdle together with the humerus of *Chalcides tridactylus*, 11. Vestigial shoulder girdle of *Anniella pulchra* showing relationship to the cervical ribs. Magnification 6×.



Figs. 12-16: 12. Shoulder girdle of *Lacerta erhardi riveti*. 13. Side view of the right side of the shoulder girdle of *Eumeces skiltonianus* showing the suprascapula. 14. Shoulder girdle of *Brachymeles gracilis*. 15. Shoulder girdle of *Eumeces skiltonianus*. 16. Vestigial shoulder girdle of *Acontias percivali* showing relationship to the cervical ribs. Magnifications 6×.

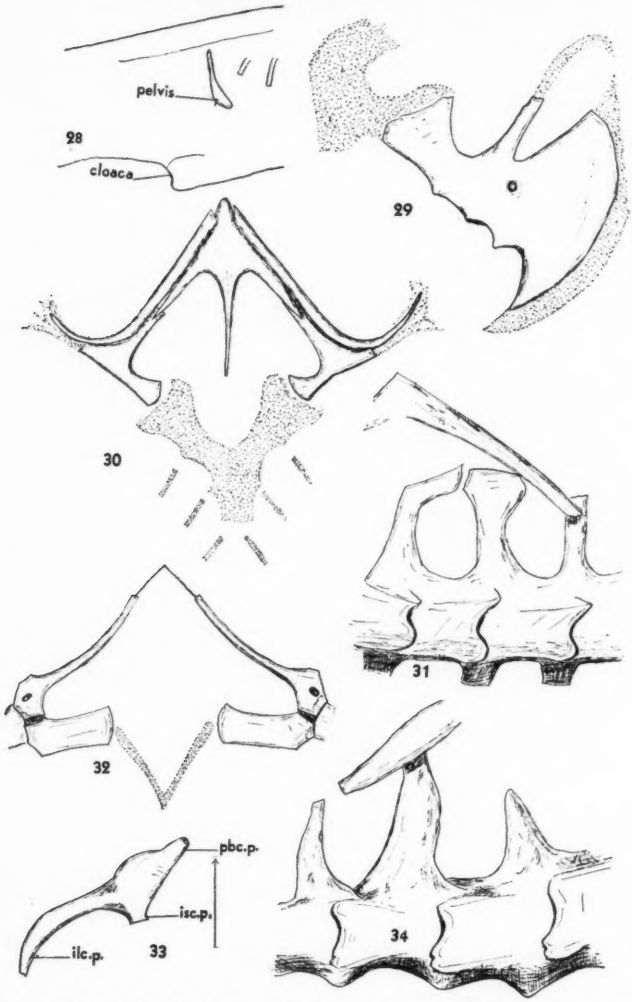


Figs. 17-21: 17. Shoulder girdle of *Chalcides sepsoides*, 18. Latero-ventral view of the right half of the shoulder girdle of *Chalcides sepsoides* showing the humerus also, 19. Shoulder girdle of *Chalcides striatus*, 20. Shoulder girdle of *Chalcides tridactylus* but without the precoracoids or scapulae, 21. Latero-ventral view of the right half of the degenerate shoulder girdle of *Anguis fragilis*. Magnifications 6×.



Figs. 22-27: 22. Degenerate shoulder girdle of *Anguis fragilis*. 23. Side view of the pelvis of *Chalcides sepsoides* showing relationship to femur and sacrum. 24. Pelvis of *Chalcides sepsoides* (ventral view). 25. Pelvis of *Chalcides striatus* (Shows a more advanced stage of degeneracy, ventral view). 26. Pelvis of *Chalcides tridactylus* (Shows an early stage of degeneracy, ventral view). 27. Vestigial pelvis of *Anniella pulchra* (Left side, showing relationship to vertebral column and cloaca).

Abbreviations: *EP* = epipubis, FE = femur, *IL* = ilium, *ISCH* = ischium, *PF* = pubic foramen, *PP* = pectineal process, *PUB* = pubis, *TI* = tuber ischii. Magnifications 6×.



Figs. 28-34: 28. Vestigial pelvis of *Acontias percivali* (Right side, showing relationship to vertebral column and cloaca), 29. Latero-ventral view of the right half of the shoulder girdle of *Brachymeles schadenbergii*, 30. Reduced shoulder girdle of *Ophoides striatus*, 31. Ilium and sacrum of *Ophoides striatus*, 32. Degenerate pelvis of *Ophoides striatus*, (ventral view), 33. Right half of degenerate pelvis of *Anguis fragilis*, 34. Ilium and sacrum of *Anguis fragilis*.

Abbreviations: *ilc.p.* = iliac process, *isc.p.* = ischial process, *pbc.p* = pubic process. Magnifications 5×.

The Winter Foods of Some Indiana Owls*

Charles M. Kirkpatrick and Clinton H. Conway

The well-known writings of Errington and his colleagues on predator-prey relationships, summarized by the great horned owl report (Errington *et al*, 1940), are so comprehensive that little can be added to the subject particularly as regards the food habits of owls based upon pellet analyses. Nevertheless, the present report may be of general interest since it demonstrates the emphasis received by a single prey species, *Microtus o. ochrogaster*,** from four species of owls occurring in Tippecanoe County, Indiana. The fall and winter of 1946-47 have been seasons of *ochrogaster* abundance if not peak population levels. Irrespective of the different habits of the four owl species, their foraging has carried them universally into the habitat of *ochrogaster* which was the most frequently encountered prey item in the pellets of all owls, although in total bulk this prey may not be the greatest in case of the great horned owl.

The data reported here are of particular local interest in view of the dearth of facts regarding the food habits of Indiana raptors. The information will be useful in the defense of raptors which are sometimes unjustly persecuted due to public misuderstanding concerning the effect of raptors on agricultural activities and upon populations of small game.

The discovery of roosting sites of long-eared owls, short-eared owls, and great horned owls within the space of a few weeks led us to exploit these sources of pellet material. All pellets excepting some from the barn owl were collected during the winter of 1946-47. The technique of analysis was in general that described by Errington (1930). Some specific methods are included under the owl species discussed.

Barn Owl
(Tyto alba pratincola)

A barn owl roosting site in the chute of an unused silo on the Purdue farm was first discovered in September, 1942. Since then a single owl of this species has used this roosting site irregularly until November, 1946, when the silo was filled and the bird was forced to depart. During the summer of 1942, this species nested on the dried ensilage which was only a few yards from the silo roof. Presumably different individuals used the roosting perch in the chute at different periods. Pellets dropped to the floor below were collected during the fall and winter months from September, 1942 until November, 1946.

The results of the analysis of 145 complete pellets thus obtained are shown in Table 1. The contents of the 1946 pellets are separated from those of the 1942-43 pellets but the diet seems to have changed very little from a qualitative standpoint.

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** Scientific and common names after Bole and Moulthrop (1942).

An item of prey was considered a complete individual only when the cranium and both mandibles were present. Otherwise, when any of the parts were missing, the wanting member or one like it, when found as an extra part in another pellet, was combined with the incomplete skull to make a complete individual which was thus recorded. In spite of this pooling of extra skull parts, a few incomplete prey items remained.

In 145 pellets examined, remains of at least 395 vertebrates were found, of which all but 4 birds were mammals. The most frequently occurring species was *Microtus o. ochrogaster*. In a large series of barn owl pellets examined in Michigan (Wilson, 1938)) and in a smaller series from Ohio (Price, 1942), *M. p. pennsylvanicus* leads as the most frequently occurring species while *ochrogaster* was not detected at all. This may be expected since *ochrogaster* is more abundant locally than *pennsylvanicus*, while the latter replaces the former in most of Michigan. The Purdue silo owls show a notable lack of attention to the house mouse *(Mus m. musculus)* and the Norway rat *(Rattus norvegicus)* although within the immediate vicinity of the roosting quarters a score or more of large barns, cribs and feeding sheds offered innumerable opportunities to prey upon these pests known to be present. Considering the propensity of the great horned owls for preying upon rats, although their hunting territory included a variety of habitats, one suspects that the smaller barn owl is scarcely a match for full grown rats. On the other hand, the infrequent occurrence of *Mus* in the barn owl diet gives rise to the suspicion that the barn owls simply hunt elsewhere than on the University farm property where a certain amount of activity and lighting may be a disturbing influence.

A dozen skulls of the lemming mouse *(Synaptomys cooperi saturatus)* were recovered from the pellets which up to that time represented the first record of that genus in Tippecanoe County, Indiana. No *Synaptomys* had entered our traps in spite of a great deal of trapping in likely habitats. More recently a total of four individuals of this species has been taken but we are still not as successful as the barn owl in capturing this species. With regard to the barn owls' superior efficiency in catching small mammals, the situation described for *Synaptomys* was also encountered with the common occurrence of *Cryptotis* in the owl pellets. Until early fall of 1946, only three specimens of this shrew were recorded for Tippecanoe County although the presence of 47 individuals in the owl pellets indicated their common occurrence. In the fall of 1946, however, the authors discovered some apparently excellent *Cryptotis* habitats which with improved trapping technique permitted us to take this species almost at will (Kirkpatrick and Conway, 1948). Bole and Moulthrop, (1942), have also noted that *Cryptotis* is more abundant than trapping records show as indicated by its regular occurence in owl pellets.

Bole and Moulthrop observe that *Blarina* is the commonest mammal in this region and our interpretation that they refer to its universal distribution in mixed habitats is substantiated by our recent trapping activities, but the *Blarina* catch of the barn owls takes no better than third place. A direct comparison between the owls' catch and our own is unwarranted in view of many variable circumstances, but our observation has been that in certain limited habitats

TABLE 1.—Analysis of Barn Owl Pellets from Tippecanoe County, Indiana.

Prey Species	Complete Prey items	
	134 pellets Sept. '42-Dec. '43	11 pellets Nov. '46
Gray Cryptotis (*Cryptotis parva harlani*)	34	13
Lake States Blarina (*Blarina brevicauda kirtlandi*)	52	6
Deer Mouse (*Peromyscus* spp.)	35	2
Illinois Lemming Mouse (*Synaptomys cooperi saturatus*)	12	1
Eastern Meadow Vole (*Microtus p. pennsylvanicus*)	68	3
Middle Western Prairie Vole (*Microtus o. ochrogaster*)	103	18
Microtus spp.	30	
Norway Rat (*Rattus norvegicus*)	2	
House Mouse (*Mus. m. musculus*)	9	2
Cottontail (*Sylvilagus floridanus mearnsii*)	1	
Bird	4	

the microtine rodents (particularly *M. ochrogaster* in the drier fields) surpass all other mammals in abundance. Thus it may be inferred that hunting in this sort of habitat is strongly attractive to barn owls which perhaps explains their emphasis upon *M. ochrogaster* rather than upon *Blarina*.

Specific identification of the *Peromyscus* was not attempted. In all probability both *P. leucopus noveboracensis* and *P. maniculatus bairdii* are represented.

With the exception of one pellet containing some cottontail rabbit remains, there was no evidence of predation upon game. Bobwhite quail *(Colinus v. virginianus)* and pheasants *(Phasianus colchicus torquatus)* as well as cottontails *(Sylvilagus floridanus mearnsii)* were known to be within easy range of the owls' roosting site. Bird remains found in the pellets were from small passerines.

LONG-EARED OWL
(Asio wilsonianus)

In the early winter of 1946-47, a small number of long-eared owls were discovered using a two-acre conifer plantation consisting mostly of pine and spruce species. On numerous occasions three to five of these owls were flushed from this cover located on the Purdue Horticulture Farm near West Lafayette in Tippecanoe County. The plantation is situated at the edge of an apple orchard of approximately 40 acres, the ground cover of which is predominantly blue grass sod. Adjoining the plantation on the west is a rather extensive acreage of ungrazed brush and some pasture including scattered timber, ravines, and a few low spots probably harboring *Microtus p. pennsylvanicus*.

The tendency of long-eared owls to form colonies in winter has been noted by several observers (Bent, 1938), and the habit simplifies the collection of their pellets for a seasonal food habits survey. Without much difficulty we were able to collect 83 whole pellets and 139 additional pieces of regurgitated material which might have been either whole pellets or fragments. The pellets of this species are rather loosely formed and undoubtedly separate easily as a result of striking branches on the descent to the ground beneath the owls' perch.

The analysis of the prey remains composing this material is given in Table 2. The procedure for the identification of the prey was the same as that described above for the barn owl pellets.

TABLE 2.—Analysis of Long-eared Owl Pellets from Tippecanoe County, Indiana.

Prey Species	Complete prey items	
	83 complete pellets	139 whole pellets or fragments
Gray Cryptotis (*Cryptotis parva harlani*)	15	7
Lake States Blarina (*Blarina brevicauda kirtlandi*)	1	2
Deer Mouse (*Peromyscus* spp.)	16	14
Illinois Lemming Mouse (*Synaptomys cooperi saturatus*)	3	4
Eastern Meadow Vole (*Microtus p. pennsylvanicus*)	22	18
Middle Western Prairie Vole (*Microtus o. ochrogaster*)	95	86
Cottontail (*Sylvilagus floridanus mearnsii*)	tr	
Bird	2	6

The occurrence of *Microtus o. ochrogaster* as the most important item of diet is expected since this species occurred rather abundantly in the grass cover of the land about the roosting site. Apparently, the University follows a routine poisoning program in the orchard. Nevertheless, signs of small mammal activity are evident within the orchard although runways, burrows, and middens are much less extensive than in similar unpoisoned habitat.

It is doubtful if *M. P. pennsylvanicus* occurred within the area of the orchard trees, but more likely that it came from lower spots in the brush and pasture. The occurrence of *Peromyscus* spp. probably represents forays into the brush and sparsely timbered grazing land. Traps which we set in the orchard on different occasions produced only *M. o. ochrogaster, Synaptomys,* and *Blarina.*

It is impossible to say whether the main part of the owls' catch of *ochrogaster* came from the orchard or the adjoining fields. In either case the long run effect of predation upon this microtine would be beneficial to the interests of the orchard, at least to the extent of eliminating a certain number of potentially destructive rodents already in the orchard or representing possible immigrants.

Upon the basis of comparative numbers found in pellets, it appears that the habits of *Synaptomys* render it less vulnerable as raptor prey than do the habits of *ochrogaster* and the *Peromyscus* spp. whose activities often carry them into open runways and exposed situations. Only seven individuals of *Synaptomys* were found in the long-ear pellets, leading us to suspect that the characteristic, covered runways in dense stands of bluegrass give a certain amount of protection to the species from winged predators. Although we have taken but a few *Synaptomys* from this locality in our traps, the lemming mouse is notably difficult to capture in large numbers by this means (Hamilton, 1943).

With the exception of cottontail fur in one pellet, no other signs of game species were found. For the part of the year represented by these pellets, it appears that long-ear feeding habits have slight, if any, effect upon game populations in this vicinity. The remains of eight birds were small passerines.

SHORT-EARED OWLS
(Asio flammeus flammeus)

In December, 1946, a congregation of short-eared owls was discovered in the southeastern part of Tippecanoe County, Indiana, in a community devoted to intensive farming. The owls were flushed in varying numbers on different occasions from two fields of wheat stubble which were about a mile apart. On one day 13 birds were observed and 11 on another. On December 20, the authors flushed eight owls from an area of about five acres.

The presence of the owls probably represented an influx to an area of good food supply. Their use of the wheat stubble for roosting was indicated by numerous pellets deposited there. During visits made to these areas on December 18 and 20, we were able to collect more than 400 complete pellets. Almost invariably pellets were found in the immediate vicinity of a deposit of greenish-white excrement and this striking mark upon the straw or ground

was the clue to the location of the less noticeable, drab pellets scattered widely in the stubble. The interval over which the pellets were deposited is not known although the presence of grasshopper remains in one pellet may indicate a meal taken early in November.

Such local gatherings of this species in the neighborhood of a good food source apparently is common in winter (Bent, 1938; Butler, 1897), and others have taken advantage of the opportunity thus offered to study the food habits of this owl. Snyder and Hope (1938) examined a large number of pellets from the Toronto region and found that more than 99 percent of the individual items identified from the pellet remains were rodents. Of these the meadow vole *(Microtus pennsylvanicus)* comprised more than 70 percent. More recently a concentration of short-eared owls in late winter was observed simultaneously with a high *Microtus* population in New York. (Terres and Jameson, 1943). In this case *M. pennsylvanicus* represented 82.1 percent of the small mammals found in 142 pellets. Previous observations made on the foods of this species in Indiana have been cursory. Butler (1897) states that of 10 birds taken in the winter of 1886-87 in Putnam County, nine contained the remains of mice. Price (1942) reported that "several pellets" found in Allen County contained six individuals of *Peromyscus* spp. Earlier, Errington (1932) observed that short-eared owls seem to have a distinct preference for small mammals. This apparent preference seems to have been borne out by the results which are reported here as well as those from Canada and New York. Nevertheless, it should be noted that the owl concentrations herein mentioned apparently were in response to the high populations of rodents, and the principle of the predator feeding upon that prey item which is most abundant and easiest to catch may be operating in these cases.

The identification of prey items in 100 pellets is shown in Table 3.

TABLE 3.—Analysis of Short-eared Owl Pellets from Tippecanoe County, Indiana.

Prey Species	100 pellets	
	Complete prey items	Incomplete prey items
Gray Cryptotis (*Cryptotis parva harlani*)	1	
Lake States Blarina (*Blarina brevicauda kirtlandi*)	1	3
Deer Mouse (*Peromyscus* spp.)	3	1
Eastern Meadow Vole (*Microtus p. pennsylvanicus*)	6	1
Middle Western Prairie Vole (*Microtus o ochrogaster*)	154	24

Cottontail (*Sylvilagus floridanus mearnsii*)	t.
Poultry	tr.
Bird	1
Grasshopper	6

STATISTICAL TREATMENT

To determine if the examination of 100 pellets gives reliable information, the data have been analyzed statistically by a method which uses a tabulation of *Microtus ochrogaster* which makes up the bulk of the pellet contents. When two first lower molars were present, this was counted as one mouse; if two pairs, two mice, etc. If an odd molar was present, this was counted as ½ assuming roughly an even chance that the bulk of the mouse was in another pellet. Taking the contents of each pellet in turn, the following table was obtained:

Microtus o. ochrogaster

Number in pellets	Number of pellets with such content
0	5
½	4
1	33
1½	10
2	27
2½	8
3	11
3½	0
4	2
	100

The mean and standard deviation are calculated. These figures are respectively the average (number of mice per pellet) and the average discrepancy from the mean. The mean is merely the sum of the individual numbers divided by how many there were. The standard deviation is the "root-mean square" type of average discrepancy which is most easily found as below. For calculation the first column above is called "X" and the second "f" and "X.f" and "X2.f" are also formed as columns. The last three columns are added.

X	f	X.f	X2.f
0	5	0	0
½	4	2	1
1	33	33	33
1½	10	15	22.5
2	27	54	108
2½	8	20	50
3	11	33	99
3½	0	0	0
4	2	8	32
	100	165	345.5

Average (mean)

$$\bar{X} = \frac{165}{100} = 1.65 \text{ mice per pellet.}$$

Variability (standard deviation)

$$\sigma_X = \sqrt{\frac{345.5}{100} - \left(\frac{165}{100}\right)^2}$$

$$= \sqrt{3.455 - 2.7225}$$

$$= .856 \text{ mouse per pellet}$$

These figures are used to calculate the true average pellet content of *ochrogaster* in short-eared owl pellets under similar conditions. For this $\frac{\sigma}{X}$ is used, which in contradistinction to σ_X, is the amount by which the average $\bar{X}$ may be expected to be off from the true average pellet content.

$$\frac{\sigma}{X} = \frac{\sigma_X}{N} = \frac{.856}{100} = .0856$$

Thus the obtained average of 1.65 mice per pellet may be reasonably supposed to differ by .086 from the true average whatever it may be. It is almost certain that the observed average of 1.65 is not off by over 3 X .086 or .26. Thus the probable true average content of *ochrogaster* in short-eared owl pellets under these conditions does not lie below 1.65 − .26 = 1.39, nor above 1.65 + .26 = 1.91. Probably it is quite close to 1.65. Thus 100 pellets give quite substantial information.

In the statistical treatment we have had the assistance of Dr. I. W. Burr, Associate Professor in Mathematics, Purdue University.

The occurrence of the prairie vole *(M. o. ochrogaster)* comprises 94.4 percent of the mammalian items. The high incidence of this species in the owl's diet is not surprising since it coincides with our observations of the unusual abundance of *M. o. ochrogaster* during the fall and early winter of 1946. Only six individuals of *M. p. pennsylvanicus* were recovered. This was according to our expectations since in this locality we regard *M. p. pennsylvanicus* as being associated with the low or wet-meadow type of grassy habitat, and in the area of the short-eared owl concentrations little of this habitat occurs.

The extent to which our analyses of four species of owl pellets have progressed revealed that the short-eared owl produces pellets with less readily recognizable contents than any of the other species. Perhaps this is due to the extreme efficiency of digestion since only rarely were the usually resistant mandibles found. The extraordinary compaction of the fur into comparatively smooth-surfaced pellets was also noted. Perhaps the manner in which these owls handle their prey accounts for the difficulty of finding large bone fragments of diagnostic value. One individual of this species which was held for

some time in our laboratory was observed to tear up its prey rather thoroughly, usually rending a *Microtus* head into three to ten small bites while holding the rest of the body in its talons.

In our specific identifications of the *Microtus* most determinations were made from the presence of a similar pair of first lower molars. In most pellets the teeth were the only remaining material permitting identification of the mammal from which it originated. In *M. ochrogaster* five enamel loops are found on the first lower molar, whereas seven are present in the case of *M. pennsylvanicus*. Single teeth of this kind were found a number of times, and these were designated as incomplete individuals since the other of the pair may be found in another pellet.

It seems appropriate to point out that the eight short-eared owls noted by the authors and habitually using a stubble field were sharing this field with a small number of pheasants also roosting there. On the basis of our pellet studies, the owls had no effect on the pheasants. Within one mile of the owl roosting cover, there were known to be two coveys of bobwhite quail, but we have no evidence of their suffering in the least as a result of the raptors' congregating in the vicinity, thereby increasing the total predator demand for food. Cottontail rabbits are common in the vicinity of the owls' hunting territory, but only a trace of cottontail fur was found in one pellet. An owl as small as a short-ear probably would be incapable of routinely subduing vigorous, full-grown cottontails even if smaller more abundant prey were not readily available. Predation upon juvenile cottontails is quite another matter.

It seems likely that the owls concentrated in this area because of a high *M. ochrogaster* population and that this rodent fulfilled to a large extent the food requirement of the owls.

GREAT HORNED OWL

(Bubo virginianus virginianus)

A total of 102 pellets were collected from three great horned owl territories one of which was occupied by a pair which later nested. The territory headquarters in each case were in thin to heavy deciduous woods surrounded by pasture and cropland. Pellets were usually found in concentrations beneath favorite roosting sites and collections were made in January, 1947.

The identification of the prey items is shown in Table 4. In the first column is expressed the total number of times each prey item was represented in pellets but in most cases this number is not necessarily the actual number of individuals eaten. As stated by Errington *et al* (1940) "a given victim may serve as food for more than one owl or as more than one meal for a single owl." For example, remains of the cottontail were noted a total of 40 times but after assembling jaw bones, vertebrae, and other recognizable parts into more or less complete skeletons, only ten cottontails could be definitely accounted for. This figure then represents the minimum number of cottontails which were fed upon. It is possible or perhaps even likely that more cottontails were fed upon, but unless all pellets formed by the owls were found, it would not be possible to state with certainity the maximum number of cottontails eaten.

TABLE 4.—Analysis of Great Horned Owl Pellets from Tippecanoe County, Indiana.

Prey Species	102 pellets	
	Prey items represented	Minimum prey items accounted for
Gray Cryptotis (*Cryptotis parva harlani*)	7	4
Lake States Blarina (*Blarina brevicauda kirtlandi*)	3	3
Deer Mouse (*Peromyscus* spp.)	28	20
Illinois Lemming Mouse (*Synaptomys cooperi saturatus*)	3	1
Eastern Meadow Vole (*Microtus p. pennsylvanicus*)	1	1
Middle Western Prairie Vole (*Microtus o. ochrogaster*)	101	63
Norway Rat (*Rattus norvegicus*)	22	12
Cottontail (*Sylvilagus floridanus mearnsii*)	40	10
Bobwhite Quail (*Colinus v. virginianus*)	1	0
Ring-necked Pheasant (*Phasianus colchicus torquatus*)	1	0
Crow (*Corvus brachyrhynchos*)	1	0
Bird (incl. 9 Starlings)	26	0
Poultry	2	0
Insect	2	2

A larger number of *Microtlus o. ochrogaster* were taken than any other species which points to the propensity of these great horned owls to leave their woodland retreats in order to hunt open habitats for this abundant grassland rodent. Also notable as horned owl food is the Norway rat *(Rattus norvegicus)*. Pellets from all the owl territories contained this species although the largest number of rats were from the territory of the pair. Within their range numbers of field-living rats were to be found along fence rows and ditches adjacent to corn fields. In this connection may be noted the possible assistance

rendered by the owls to human efforts in controlling rats. Field-living rat populations ordinarily are undetected in rat control programs and, therefore, serve as sources for propagation of the pest. The attention given to such rat colonies by owls or any other predators must be regarded as beneficial to human interests.

With the possible exception of the cottontail, great horned owl predation upon local game species seems negligible. In all three owl territories bobwhite quail coveys were wintering and ring-necked pheasants were known to occur in two of the territories. Remains of only one of each of these species were found in 102 pellets. Errington (1936) has pointed out that whereas the horned owl possibly takes more quail (north-central states) than any other predator, only slight losses are suffered by quail when optimum conditions of range and quail densities obtain.

SUMMARY

Some winter foods of four species of owls are reported for Tippecanoe County, Indiana. A total of 430 complete pellets were examined plus 139 whole or part pellets of the long-eared owl. In the aggregate remains of 1098 prey items were noted of which 1046 items or 95.2 percent of the total were small mammals. Of these there was a marked preponderance of *Microtus o. ochrogaster* comprising 557 individuals or 50.7 percent of all the food items. This species was locally very abundant at the time when most of the owl pellets were being produced.

Including an improbable maximum of 43 cottontails, remains of only 45 game species were found which were 4.1 percent of all the prey. Although the pellets were collected from localities which supported altogether 23 owls of four species, the great horned owls accounted for 42 of the game species. Therefore, it is concluded that for the period and place which this study embraces, general owl predation upon game species was negligible.

The great horned owl predation upon field-living Norway rats is noted as beneficial to human interests.

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Notes and Discussion

A New Variety of Croton Muelleri Coulter

Leon Croizat

In the pages of a study of *Croton* published about five years ago (Bull. Torrey Bot. Cl. **69**: 449. 1942), I had occcasion to remark that I had not seen ripe seeds of *C. Muelleri* Coult., thus leading the readers of that paper to infer that my acquaintance with this species was far from intimate. This was in reality the case.

Subsequently, thanks to Mr. V. L. Cory, I received numerous specimens and ripe seeds of *C. Muelleri* Coult., collected in southeastern Texas, thus verifying Ferguson's surmise (Missouri Bot. Gard. Rept. **12**: 56. 1901) that this species belonged indeed to the flora of the U. S. A. The material in question is now preserved in the herbarium of the Arnold Arboretum of Harvard University and I regret that in my present circumstances I can no longer refer to it by the detailed citations of *exsiccata*.

At any rate, from ripe seeds originally sent by Mr. V. L. Cory, I raised several crops of *C. Muelleri* Coult. in the greenhouse, and effected careful comparisons of this plant with *C. capitatus* Mchx., *C. Lindheimeri* (Engelm. & Gray) Wood, and the form which I then understood as *C. albinoides* (Ferg.) Croizat. Other plants of the same species and form were again raised by me in the course of the last few months in Caracas.

It appears that while my conclusions of 1942 are in the main correct, and my *C. albinoides* differs in what I still believe to be a specific degree from both *C. capitatus* Mchx. and *C. Lindheimeri* (Engelm. & Gray) it proves impossible to treat *C. albinoides* as specifically different from *C. Muelleri* Coulter. In reality the latter seems to me to be merely a variety of the former, somewhat smaller in all its parts, and having a range farther south.

In the light of these findings and observations, I propose, *Croton Muelleri* Coult. var. **albinoides** (Ferg.) Croiz. comb. nov.

> *Croton albinoides* (Ferg.) Croiz. (Bull. Torrey Cl. **69**:447. 1942).
> *Croton Engelmanni* var. *albinoides* Ferg. (Missouri Bot. Gard. Rept. **12**:55. 1901).

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Mesostoma from Utah

Stanley Mulaik

During the summers of 1943 to 1945, while checking permanent and temporary pools in the vicinity of Salt Lake City, Utah, for mosquito larvae, many other forms of water life were encountered. Among these was a rhabdocoele determined as *Mesostoma ehrenbergii wardii* Ruebush, 1940.

In 1941, Ferguson and Hays, in the Synopsis of the Genus *Mesostoma*, gave the habitat for this form as Illinois, Nebraska, Kansas, Michigan, New York and Ohio. The present specimens under consideration were taken in one temporary pool and one permanent pool south of the city. The temporary pool was formed by summer irrigation waters which were impounded between a hillside and a road fill. Specimens were taken during three summers. The permanent pool is one formed by an abandoned artesian well from which water flows constantly. Of over a thousand pools examined at least three or four times during the summer, *Mesostoma* was found only in two.

About a hundred specimens have been taken during the summer months. These generally were found with winter eggs, though several with summer eggs were observed. These eggs numbered about twenty-four in the largest live specimen observed. This measured about 10 mm in length and about 4 mm in width. A number of the adults were kept alive for some time in the laboratory, though eventually they died. Some time later young were observed in the containers, apparently having hatched from eggs.

Whether this form is a native of the region or whether it was brought from the known eastern range in the water casks of the early immigrants is not known. Its presence here extends the known range for a considerable distance.

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